SOCIETY OF ARTS, LONDON.

April 17.—Mr. ANTOINE CLAUDET read a paper "*On the Properties of the Diamond for Cutting Glass, with descriptions of machines invented by him, in which the Diamond is made to perform perfectly what by manual labour had before been very imperfectly done.*"

The author commenced his paper by a very interesting description of the nature of the diamond, of the form of its natural crystal, and of the mode in which it cuts glass,—quoting a paper on the subject by the late Dr. Wollaston, in the 'Philosophical Transactions' for 1816, as well as by a history of the use of glass in windows from the earliest times, when it was used only in ecclesiastical buildings of great splendour, down to its present universal application. He has also, in order the more thoroughly to make apparent the advantage of the use of the diamond, described minutely the very tedious and imperfect methods by which, before its introduction, glass was cut and shaped. The property in question was first found out about the time of Francis I. of France, the well-known anecdote of whom is quoted; and the different tools used from that time to the present for its manual application are detailed and commented on, many of them being exhibited by the author. The first of these was a mere handle, having the diamond firmly inserted into the lower end. But the handle being round, and the diamond, from the form of its crystal, requiring one unvarying direction to be preserved in order to produce a cut, this was found so imperfect that a step was taken by making the end of the handle flat, to preserve the parallelism against the rule. This, from the shape of the bottom in which the stone was set, was called the "plough diamond." In 1814, Shaw, of London, made a great improvement, and brought the instrument to the shape in which it is still used, by making the metallic setting of the diamond moveable on a ferrule at the bottom of the handle, thus putting it out of the power of any deviation of the hand from the proper position to affect the direction of the stone. This, perfect as it may seem, is still difficult to use, and requires long practice for expert performance. The two tests by which the workman knows when his tool is "making a cut" are, the sound and the feel. A modification of the last-named tool, by the brother of its inventor, was formerly used for those who have but little practice; but it was very little used, and the one shown to the meeting by Mr. Claudet was curious, from being, perhaps, the only one now in existence. A contrivance for cutting circular plates was shown in action.

The cause of the invention of the machines, the description of which was the principal object of the paper, was the increased use of glass shades for covering ornaments, the cutting of which, so that they should stand perfectly firm and with an even base, was a most tedious and imperfect operation when done by hand. The manufacture of these shades, which, under the name of "cylinders de verre," had long been carried on in France, was first undertaken in England, at the instance of Mr. Claudet, by Mr. Lucas Chance of Birmingham, who, in the true spirit of enlightened enterprise, notwithstanding the vexatious pressure of the excise laws, now repealed, embarked largely in the manufacture, getting workmen from France, for making both shades and the sheet glass, which had there been for some time made from cylinders. It was now, however, found that some method of cutting the bottom of the shades and cylinders must be adopted surer and less expensive than the manual method, and Mr. Claudet was driven by this necessity to invent his machine.

The principle of the machine, expressed in the fewest words, is this: The shade is firmly fixed between an internal support and a transverse bar above it, in a perfectly upright position, above a horizontal, level, and smooth table, its bottom being a few inches above the table. Upon the table travels a small but heavily-weighted base moving on castors, having springing from it two upright pillars, one holding the diamond, and the other forming a support opposite to it. The pillar holding the diamond is fixed, but the other is moveable, being by a spring kept close to it. The height of the whole is such that when on the table, the diamond is about an inch above the bottom of the shade. The diamond being introduced inside the shade as it hangs suspended, the pressure of the spring is sufficient to cause it to cut, and it has only to be moved round the shade, the horizontality of the table causing the cut to be perfectly level. This machine was exhibited, and the bottoms of shades cut by it, before the meeting. The shape of the shade, whether oval, round, or square, is unimportant in the use of this machine, but Mr. Claudet has contrived another for the cutting of round shades only, in which the shade is laid horizontally,—an elegant system of adjustments being provided, by which shades of any diameter can be cut by the workman with little risk of error. This machine was also shown in action.

May 1.—G. MOFFATT, Esq., M.P., in the Chair.

"*Abstract of a Paper on the Causes and Preventives of Mildew in Paper and Parchments; with an account of Experiments made on the saturation of growing Wood with Antiseptic Chemical Solutions.*"* By ALFRED GYDE, M.R.C.S.E.

Owing to the imperfections formerly existing in the microscope, little was known of the real nature of the class of plants called *fungi* until within the last few years; but since the improvements in that instrument, the subject of the development, growth, and offices of the fungi has received much attention. They compose, with the algæ and lichens, the class of *Thallogens* (Lindley), the algæ existing in water, the other two in air only. A fungus is a cellular flowerless plant, fructifying solely by spores, by which it is propagated, and the methods of attachment of which are singularly various and beautiful. The fungi differ from the lichens and algæ in deriving their nourishment from the substances on which they grow, instead of from the media in which they live. They contain a larger quantity of nitrogen in their constitution than vegetables in general do, and the substance called "fungine" has a near resemblance to animal matter. Their spores are inconceivably numerous and minute, and are diffused very widely, developing themselves wherever they find organic matter in a fit state. The principal conditions required for their growth are moisture, heat, and the presence of oxygen and of electricity. No decomposition or development of fungi takes place in dry organic matter; a fact illustrated by the high state of preservation in which timber has been found after the lapse of centuries, as well as by the condition of mummy cases, bandages, &c., kept dry in the hot climate of Egypt. Decay will not take place in a temperature below that of the freezing point of water, nor without oxygen, by excluding which—as contained in the air—meat and vegetables may be kept fresh and sweet for many years.

The process which takes place when moist vegetable substances are exposed to oxygen is one of slow combustion, and has been called by Liebig "*Eremacausis*," the oxygen uniting with the wood and liberating a volume equal to itself of carbonic acid; another portion combining with the hydrogen of the wood to form water. Decomposition takes place on contact with a body already undergoing the same change, in the same manner that yeast causes fermentation. Animal matter enters into combination with oxygen in precisely the same way with vegetable matter; but as, in addition to carbon and hydrogen, it contains nitrogen, the products of the *Eremacausis* are more numerous—carbonate and nitrate of ammonia, carburetted and sulphuretted hydrogen, and water: and these ammoniacal salts greatly favour the growth of fungi. Now, paper consists essentially of woody fibre forming its substance, with animal matter, as size, on its surface.

The first microscopic symptom of decay in paper is irregularity of surface, with slight change of colour, indicating the commencement of the processes just noticed; during which, in addition to carbonic acid, certain organic acids are formed—as cremic and ulmic acid, which, if the paper have been stained by a colouring matter, will form spots of red on the surface. Spots of the same kind are similarly formed on leather coloured during its manufacture. Provided that fungi have not taken root, the colour can be restored by ammonia or any alkali. The same process of decay goes on in parchment as in paper; only with more rapidity, from the presence of nitrogen in its composition. When this decay has begun to take place, fungi are produced—the most common species being *Penicillum glaucum;* they insinuate themselves between the fibre, causing a freer admission of air, and consequently hastening the decay.

The substances most successfully used as preventives of decay, are the salts of mercury, copper, and zinc. Bichloride of mercury (corrosive sublimate) is the material employed in the kyanisation of timber, the probable mode of action being its combination with the albumen of the wood, to form an insoluble compound insusceptible of spontaneous decomposition, and therefore incapable of exciting fermentation. The antiseptic power of corrosive sublimate may be easily tested by mixing a little of it with flour paste; the decay of, and appearance of fungi on which are quite prevented by it. Next to corrosive sublimate in antiseptic value stand the salts of copper and zinc. Chloride of zinc has been patented by Sir W. Burnett for the preservation of wood, sail-cloth, &c., and appears to succeed admirably. For use in the preservation of paper, the sulphate of zinc is better than the chloride, which is to a certain extent deliquescent.

A series of experiments were made by the author in the summer of 1840 on the use of metallic and other solutions for the preservation of wood. A deep saw-cut was made all round the circumference of the growing trees near their base, into which the solutions were introduced by forming a basin of clay beneath the cut; thus the solution took the place of the ascending sap, and in periods of time, varying from one to three days, was found to have impregnated even the topmost leaves of trees fifty feet high. The trees were chiefly beech and larch. After impregnation they were felled, and specimens about five feet long by two inches square cut out, and packed in decaying sawdust in a warm damp cellar, where they were left for seven years. The details of the experiment are given in a table, by which the following general results are made to appear:—The wood saturated with sulphate of copper, in the proportion of one pound to one gallon of water, or with acetate of copper, one pound to one pint of vinegar and one gallon of water, were found in perfect preservation, clean, dry, and free from fungus; the remainder, which were saturated with nitrate of soda, prussiate of potash, pyrolignite of iron, sulphate of iron, common salt, and creosote, presented much decay, and a large growth of fungi.

The results obtained from solutions of corrosive sublimate—one-eighteenth of a pound to a gallon of water (Kyan's proportion) varied in an anomalous manner.

"*On the Patent Safety Steering-Wheel of* CAPTAIN FAYRER, R.N., *and* LIEUT. ROBINSON, R.N."

Serious accidents occur to the helmsmen in large vessels from the little power which they have to resist the sudden shocks caused by the sea

* This Paper was rewarded in 1848 with the Society's Gold Isis Medal.

striking the rudder, by which the helm is often taken out of their hands, and they are either thrown overboard or much hurt. A constant experience of such accidents, during his command of the three large steamers, *President*, *Liverpool*, and *Forth*, and of the *Lady Flora*, Indiaman, led Captain Fayrer to consider some method of preventing them, and, at last, to this invention.

It consists in the application to the steering-wheel of a friction-band similar to that used in cranes, which passes round a projecting circumference inside the wheel, and is brought down to a pedal on the deck, by pressure on which any amount of friction can be put on the wheel. It is not desirable that the helm should ever be at a 'dead lock,' without the power of yielding a little to the shock of a very heavy sea, as that would endanger the carrying away of the rudder; an adjusting screw is therefore provided, by which the amount of *ultimate* friction that can be put on the wheel is regulated, and not left in the power of the steersman. A great advantage of this invention is the power which it gives of fixing the rudders of vessels lying in a tide-way or harbour, and thereby preventing the continual wear on the pintles of the rudder, and, in time, the loosening of the stern framing of the vessel. Letters testifying to the merit of the safety steering-wheel, from eminent ship-builders and naval engineers, were read. It is being applied to the large steamers *Asia* and *Africa*, now being built at Greenock, for the North American mail service. The communication was illustrated by drawings, and by a very well-executed model.

BRUSSELS ACADEMY OF SCIENCES.

Prizes are offered for the best papers on the following subjects:—

An elaborate examination of the state of our present knowledge respecting rain, and of the principal causes which serve to modify this phenomena.—Gold medal of the value of 600 francs.

To be sent in before September 20th, 1850.

To give a full account of the different researches which have been undertaken, for the purpose of preserving materials employed for building purposes, such as stones of different kinds, marble, brick, cement, stuccoes, &c., unalterable by external agents. To point out those processes which appear to have been attended with success, and to enter into a discussion of the probable causes of that success. Lastly, to point out some methods of preservation superior to those already known, which may be employed for the materials above mentioned, those methods being, on suitable theory, on experiments duly authenticated, and in accordance with that theory.—This prize, to be awarded by the Government, will consist of 1,500 francs (60*l.*) and a gold medal, of the value of 600 francs (24*l.*)

To be sent in before September 20th, 1851.

UNITED STATES NAVAL DRY DOCKS.

At the present time the United States Government have in progress four different dry docks capable of docking the largest vessel afloat. From their great size and the many improvements that have been introduced, a correspondent of the *Franklin Journal* says that they are far superior to any at present in use in Europe. Of the four now building one is at Philadelphia, and is known as the floating *sectional* dry dock. It is patented by Messrs. Dakin, Moody, Burgess, and Dodge, who are at present constructing this one for the government, a considerable portion of which is already completed, and the balance in progress. When finished this dock will consist of ten sections, each of which has the capacity to raise 800 tons—total power 8000 tons—and will take up a vessel of 350 in length. Six sections will raise a ship of the line, and the four remaining sections will raise a frigate. The sections are placed side by side, and connected by timbers at the top of the tanks. The pumps for exhausting the sections are worked by four steam-engines—two of 20 and two of 12-horse power. One of each size is used on each side of the dock, and placed so that the two 20-horse engines exhaust six sections, and the two 12-horse engines exhaust four sections, a perfect uniformity of level being maintained by suitable connections. In connection with the dock, there is a large stone basin, the sides and bottom being of granite. This basin is 350 feet long, and 226 feet wide, and contains a sufficient depth of water at ordinary high tide, to float the dock and the vessel it may contain. Immediately adjacent to, and connected with the basin, are two railways on the main land. These railways are to be of the most substantial character, and fully capable of sustaining any vessel the dock will raise. The operation of the whole is as follows:—The sections of the dock are hauled out into the river, and water let into them until they sink deep enough to allow the vessel to be floated in. As soon as this takes place, and the vessel is properly secured, the water is pumped out of the sections, and the vessel raised out of the water. When this has been accomplished, the whole is floated into the stone basin and allowed to ground on the bottom, when the vessel may be hauled on the railway. This is effected by means of a hydraulic cylinder, of 36 inches diameter and 12 feet stroke, worked by an engine of 40-horse power. If necessary, two vessels may be put on the railways, and a ship of the line and frigate left on the dock, so that the capacity of the dock is equal to four vessels of large class. When required, additional ways may be put up in connection with the basin. The whole will be completed during 1851, but some of the sections will be ready this season.

NOTES OF THE MONTH.

National Exhibition for 1851.—We have to announce that all the designs for the building will be exhibited at the Institution of Civil Engineers on the 10th June. The agitation for placing the building in Battersea Park instead of Hyde Park is taking a definite form, and is likely to be successful.

Prizes for Locomotive Engines in Austria.—An official notice has been issued by Baron Lionel de Rothschild, that the Austrian government offers six prizes for locomotive engines as follow:—A prize of 20,000 imperial ducats (10,000*l.*) for a locomotive the most suitably constructed and adapted to convey goods and passengers on the railway of the Sömring mountains, and five other prizes of the respective value of 10,000 imperial ducats (5,000*l.*), 9,000 ducats (4,500*l.*), 8,000, 7,000, and 6,000 ducats (4,000*l.*, 3,500*l.*, and 3,000*l.*) for five other locomotives, which approach nearest to the first prize in the points indicated. Plans and particulars of so interesting a competition may be had at the Imperial Royal Austrian Consulate General, New Court, St Swithin's-lane.

Great Naval Work in Russia.—In the month of February last, the great naval basin at Sebastapol was completed. The largest ships of war in the Russian navy can now be docked at that port. The basin covers an area of ten acres of ground, and has seven dry docks. The water in the basin is thirty feet above the level of the Black Sea, and the vessels are taken in by means of three locks, the iron gates of which were made by Messrs. Rennie, and are 64 feet broad, and 28 feet deep. Each of the docks has a sluice, which can be opened and the water emptied out in a very limited time, without the trouble of pumping—the plan adopted at the docks adjoining basins in this country. The Emperor of Russia is reported to have fifty ships of war at present at Sebastapol.

Aylesbury—Several plans for supplying the town with water have been forwarded to the Local Board of Health, all attended with an estimate of large outlay. P. Scott, Esq., C.E., proposes several plans, one of which is to take the supply from near Walton Mill, and erecting a pumping engine house on the Bierton elevation, the estimated cost of which will be upwards of 5,000*l.* Mr. Paten proposes a supply from Holman's-bridge stream, and an erection of steam power at the infirmary end of the town; this estimate is also over 5,000*l.* A Mr. Wrigg, an engineer from Salden, near Manchester, adopts the surface plan, and proposes several separate districts for a supply of water; each plan is estimated as costing upwards of 7,000*l.* Mr. Gotto proposes a supply from Stock Lake at a cost of 1,800*l.*; and a Mr. Gardner adopts a supply from the Friarage, and an erection of water-works in Bull Close, at a cost of 1,445*l.* A series of useful suggestions from Mr. Bell, of Leicester, was read at the meeting. To each plan there arises very difficult obstacles, and it is quite certain that if any plan of supplying the town with public water-works be adopted it will have to be done at a very great outlay.

Dover.—A kind of square vessel for the reception of machinery to be employed in breaking up and removing the solid rock at the bed of the sea where the refuge harbour is being built, whose motive power is steam, has been launched from the yard belonging to the harbour contractors, and which has been built by Mr. Cullen, ship builder, by order of Mr. Lee, the contractor of the new works. The vessel was afterwards towed into the inner harbour, alongside Mr. Cullen's yard, where it will remain until it shall have received the engines. The whole of the machinery is expected to be completed and ready for work in a short time.

Devonport.—A second attempt was made at the Keyham New Steam Docks, on the 14th, to raise the caisson, when the dam burst, and the works became inundated. The contractors, Messrs. Baker and Son, will have to repair this at their own cost. The dam was a temporary one erected for the purpose of trying the caisson, to confine the water to the lock or *spoiled dock*, and so to prevent the other portions of the work from becoming inundated during the trial. The accident, however, has obliged the parties to postpone further trial for a fortnight. Of the caisson, the *Times* correspondent gives the following account, but he has said nothing about the bursting of the work, for which the contractor was responsible:—"The water, for the first time, was let into the entrance lock on Saturday. The caisson, which is made of strong plate-iron, and is provided with a tidal valve and four sluices, measures 80 feet wide at top, 62 ft. 8 in. at the bottom, is 43 feet deep, and when immersed, gives a roadway across of 13 ft. 6 in. The weight is about 300 tons, and 150 tons of pig-iron ballast had been placed at the bottom to throw her upright. This quantity proved, however, totally inadequate, and labourers from the dockyard have been since employed throwing in additional ballast. It has been calculated that, taking the length of the caisson as 70 feet, breadth 14 feet, depth 41 feet, and weight 300 tons, her light draught, when upright, would be 10 ft. 10 in.; and that 300 tons of ballast would make her load draught 21 feet, at which point the centre of gravity would be sufficiently reduced to place her under command for bringing her to the grooves. 'This mode of closing docks is quite new in England. There is a caisson at Malta which answers well the desired object.'" The latter part of the statement is absurd, there are lots of caissons in England, as the eminent constructor of them, Mr. Fairbairn, well knows.

South Wales Railway.—The works are proceeding rapidly, and it is expected that a single line of rails will be completed between Chepstow and Swansea about the 10th of this month, and that this portion of the line will be ready for traffic early in July.

Presentation of the Royal Gold Medal to Mr. Barry, R.A.—The presentation of the Royal Gold Medal to Mr. Barry, at the Institute of British Architects, took place on the 28th ult, in presence of a very numerous meeting of the fellows and associates, and over which Earl de Grey presided. His lordship having expressed the satisfaction he felt in being called to the chair, and returned thanks for the honour done him, said it was the third year in which the prize had been distributed, and he thought it would be admitted by all that the council of the Institute had shown the greatest possible impartiality (Cheers.) The present year brought them great satisfaction, in that the honour was conferred upon one of their own body. His lordship then addressed himself to Mr. Barry, and, having made some allusions to the difficulties which had been encountered by Sir C. Wren in building St. Paul's Cathedral, said he was sorry that the august assembly which had the most to do with the erection of the new Houses of Parliament had in it a vast number of men who asked questions, made suggestions, and made criticisms, while at the same time they did not know what was wanted, or what they wanted themselves. (Cheers.) The noble chairman then presented the medal to Mr. Barry, amidst long-continued cheers from those present.—Mr. Barry, in expressing his thanks for the honour done him, said he felt sensibly alive to the defects of the great work upon which he was employed. He received the mark of approbation conferred upon him as a pledge of the opinion of the Institute that so far as he had been permitted to carry out his design, it had not been entirely unsuccessful. (Loud cheers.) He should always consider the honour done to him as one of the proudest memorials of his professional career.

Rewards, &c., for Scientific Purposes.—The following is an account, in detail, of the manner in which the 1000*l.* voted annually for rewards, experiments, and other expenses, for scientific purposes during the last two years, has been expended:—1847, 1848—Salary of Mr. J. W. Hay, as chemical lecturer at Portsmouth Dockyard, between Jan. 1 and June 30, 1847. 37*l.* 10*s.*; payment to Dr. Andrew Ure, for making an analysis of coal from Vancouver's island, 10*l.* 10*s.*; entertainment of Mr. F. P. Smith, patentee of the screw-propeller, on board the *Fairy*, tender to her Majesty's yacht *Victoria and Albert*, 15*l.* 9*s.*; compensation to Lieutenant Julius Roberts, Royal Marine Artillery, for his services and expenses while improving the method of pivoting guns, from the year 1845 to 1848, 250*l.*; total, 318*l.* 9*s.* 1848, 1849—Payment to Mr. A. G. Carle, for rock apparatus, &c., supplied for trial at Harwich, for the purpose of effecting communication with stranded vessels, 31*l.* 8*s.*; gratuity to Mr. J. T. Townson, for his services in preparing tables for great circle sailing, 100*l.*; payment to Mr. John Pridau, metallurgic chemist, for various analyses of copper sheathing, &c., for the committee on metals, 17*l.* 1*s*; payment to Mr. Charles Brooke, for his invention and establishment at the Royal Observatory, of the apparatus for the self-registration of magnetical and meteorological phenomena, 500*l.*; gratuity to Commander H. B. Weston, of the Hon. East India Company's service, for discovering a method of finding the longitude by chronometer at sunrise and sunset, with tables, 100*l.*; total, 748*l.* 9*s.* 1849-50—Allowance to Commander A. B. Beecher, to defray the expenses incurred by him in the editorship of the *Nautical Magazine*, 50*l.*; allowance to Mr. James Gordon, to enable him to publish a work, intituled, 'The Lunar and Tide Tables,' 50*l.*' total, 100*l.*

Parochial Registers.—Mr. W. Downing Bruce, F.S.A., of the Middle Temple, has addressed a letter to Mr. M. Milnes, M.P., on the necessity of a general Record Office being erected. The state of the registers at the present time is most deplorable; and there can be no question but that this subject requires the immediate attention of the legislature.

Fittings for the Arctic Expedition.—Excepting iron bulkheads for coal holes or side bunkers (an improvement), Downton's pumps worked on lower deck, and Sylvester's heating apparatus being extended 10 feet before foremost cabins on lower deck, all is as the *Enterprise* was. All the scuttles, or deck lights screw in and out for ventilation fore and aft: and Sylvester's stove having a current of air direct by a tube from upper deck will carry off much of the damp or condensed vapour, the ill effects of which were experienced in the last voyage. Of boats each ship has—1st, a life boat 30 feet long and 9 feet beam, built by White of Cowes; 2nd, one diagonal cutter, 25 feet long, 7 ft. 2 in. beam, fitted with trunks and windlass for laying out or weighing an anchor. Then four of 25 feet clinker-built gig cutters, or combination boats, pulling six oars, each single banked. One 25 feet whale boat of four oars as captain's gig; and one 12 feet dingy, and one 7 feet punt, the last about 80 lb. weight, and would convey safely two men at a time; in addition, they have one large and one small india rubber or Macintosh boat inflated by bellows. Total of boats, 9 of wood and 2 of air-tight india rubber Macintosh. The sledges are similar to those constructed for last expedition, but wider shoeing on the sole of the runners; the flat sledges are 6 inches wider and 2 feet longer than the last were, with a high curve in forepart. There is a gutta percha oblong trough fitted on the top of the travelling sledge, that is supported by 4 small iron uprights, passing through upper part of the sledge. This trough serves to hold the articles stowed or being strapped to the sledge, and will from its buoyancy make a tolerable boat, being only about 18 lb. weight, yet will support 6 cwt. in the water. They have a large yet light cooking apparatus, capable for baking for all hands, or heating washing water for the men, with a small proportion of fuel; they have also very compact light cooking apparatus heated by spirits of wine, and prepared cloth for tents, with bamboo poles for ditto. All the ships have been furnished with several new instruments, one of which is the Bearing Plate, the invention of Captain Johnson, R.N., F.R.S. They are for the purpose of ascertaining with greater certainty the ship's course in *dark weather*, and are particularly useful on board all steam vessels. The Lords of the Admiralty had them made by their instrument-maker (Mr. West, of the Strand) who also furnished some compasses and theodolites made of copper, to avoid any magnetic influence, and with other improvements by Captain Johnson, which are calculated to be of the greatest possible advantage to the expedition. The equipment for the travelling parties of the expedition has been arranged entirely by Lieutenant M'Clintock. It comprises 18 tents, each to hold seven persons, 18 mackintosh floorcloths, bamboo tent poles, hair rope; tin travelling kettles with spirit lamps and spun glass wicks; 14 large sledges upon runners; 12 small flat sledges for soft service; tin cans of two and four gallons each, the bung covered with a cap, which also serves as a gill measure, and secured with a padlock; pocket chronometers, pocket sextants, telescopes, and compasses; 40 gallons of spirits of wine; two wolf skin blankets for each tent; one thick blanket bag for each person to sleep in; eight gutta percha sledge tops, to adapt the sledges to crossing narrow spaces of water as rafts or boats, and thus avoid the necessity of unloading and using a boat; six of Lieutenant Halket's inflated boats; and 30 balloons to each ship.

Improvements in Electric Telegraph Batteries.—In most of the electric telegraph establishments, are batteries formed of zinc, copper, and sand, moistened with dilute sulphuric acid—this sand being strongly pressed between the metallic plates. These batteries, however much an improvement over those formerly employed, possess the great disadvantage of diminishing in force, requiring the frequent application of the dilute acid, and a complete removal once in every four or six weeks. M. W. Eisenlohr, the superintendent of the electric telegraphs in the Grand Duchy of Baden, has for some time past endeavoured to find out some method of rendering the battery more constant in its action, and at the same time less liable to the carelessness of the workmen, who sometimes put too much acid, and at other times leave the battery quite dry, thus producing a great interruption in the working of the telegraph. After various experiments on the subject, M. Eisenlohr found that the employment of a solution of bitartrate of potash in acidulated water for the zinc couples of a Daniell's battery, and of a moderately concentrated solution of sulphate of copper for the copper element, fully and effectually answered the desired object. This battery was found to possess a remarkable constancy. M. E. Watermann, in speaking of this new battery in the last number of the *Bibliothèque Universale* of Geneva, states that he has made use of Daniell's battery of ten couples, charged on M. Eisenlohr's system, but placing the zinc couples in acidulated water, and the copper in a solution of bitartrate of potash, and that the battery, which remained in action for three weeks, without any interruption, exhibited the most perfect constancy.

The Great Harbour of Refuge at Holyhead.—The want of a great harbour of refuge on this exposed coast has long been felt; and when it is borne in mind that the greater portion of the vast fleets destined for Liverpool must pass near Holyhead, the national importance of such an undertaking cannot be exaggerated. Plans by Mr. Walker and Captain Beechy, R.N., were rejected, and one on a more important scale by Mr. Rendel, who has carried out several great public works, was adopted by the Admiralty early in 1846. The estimate is 700,000*l.*, of which the Chester and Holyhead Railway Company have agreed to find 200,000*l.* The works were soon commenced, but have gone on rather slowly, and 10 or 15 years will probably elapse before they are completed. A visit to the scene of this great undertaking is one of the chief attractions of Holyhead. Nature has given Mr. Rendel valuable aid. There is a point called Penrhyn, about 1½ mile to the north-west of the present harbour, whence an indented rocky coast runs south-east. Considerably within this, at Soldier's Point, a gigantic breakwater is in progress, the stone for which is procured from a quarry in the mountain, one mile inland, to which a railway of prodigious guage, for stone trucks, worked by locomotives, up a very steep incline, has been formed. The breakwater will terminate at Platter's Buoy, and a pier of 7500 feet will be carried from Ynys Gybi, with its head resting on the Outer Platter. The arena inclosed within this half-moon will be 316 acres; the length across will be ¾-mile. There will be a jetty in the centre, and ample depth of water (none less than 6½ fathoms) at all states of the tide.

Steam Haulage on Rivers and Canals.—An experiment has lately been tried, with complete success, on the Gloucester and Berkeley Canal, of a somewhat novel steam-tug for hauling vessels instead of horse-power. It consists of a continuous flexible rail, or bar of iron, running the whole length of the canal, and made fast at each terminus. Above the deck of the tug are fixed a pair of rollers, between which this flexible iron band is placed, and as they are made to revolve by the steam engine on board, the grip which they take propels the boat. On the trial in question, after hauling various small craft of from 70 to 80 tons burden, she took in tow a Greek brig, laden with corn to the amount of 350 tons, which she towed against a head-wind to the dock entrance, at a good walking pace. She hauled the common canal boats at a rate of 6 miles an hour, the speed being but little affected when going against tide. The cost of hauling in the Severn is a heavy *item* in the transit of goods, and this invention is calculated to diminish the expense 59 per cent., the consumption of coal being only 25 lb. per hour.

Effluvia Trap.—We have seen a patent effluvia trap of Mr. Marsden's, which well answers the purpose. It is constructed in the shape of a drum, with four receivers, caused to revolve by the weight of the water falling into one of them. It is impossible for this trap to get choked up, or for any effluvia to escape.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM APRIL 23, TO MAY 23, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

Pierre Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for a new and improved mode of conducting consuming, and disengaging smoke from its deleterions components. (A communication.)—April 23.

Ernest Werner Siemens, of Berlin, Prussia, electric engineer, for improvements in electric telegraphs.—April 23.

Joseph Jean Baranowski of London, gentleman, for improvements in machinery for counting, numbering, and labelling.—April 23.

William Gilbert Elliott, of Blisworth, Northampton, gentleman, for improvements in the manufacture of bricks, tiles, and pipes, and other articles from plastic materials. (A communication.)—April 27.

Charles May, of Ipswich, engineer, and Robert Leggett, of the same place, foreman of mechanics to Messrs. Ransome and May, of the same place, for improvements in machinery for thrashing and grinding corn, for cutting straw, and other similar substances; also improvements in applying steam-power to give motion to such classes of machinery; and also improvements in machines for depositing seed.—April 30.

George Michiels, of London, gentleman, for improvements in treating coal and in the manufacture of gas, and also in apparatus for burning gas. (A communication.)—April 30.

Evan Protheroe, of Austin-friars, London, merchant, for improvements in the manufacture of oxide of zinc, and in making paints from oxide of zinc. (A communication.)—April 30.

Robert Dalglish, of Glasgow, merchant and calico printer, for certain improvements in printing, and in the application of colours to silk, cotton, linen, woollen, and other textile fabrics.—May 7.

Gustave Eugene Michael Gerard, of Paris, France, for improvements in dissolving caoutchouc (Indian-rubber) and gutta percha.—May 7.

George Hurwood, of Ipswich, Suffolk, engineer, for improvements in grinding corn and other substances.—May 7.

Joseph Gibbs, of Devonshire-street, Portland-place, Middlesex, civil engineer, for improvements in artificial stone, mortar, and cements, and in the modes of manufacturing the same.—May 7.

John Tatham and David Cheetham, of Rochdale, Lancaster, machine makers, for certain improvements in machinery or apparatus and operations connected with the manufacture of cotton, wool, silk, and other fibrous substances and fabrics, and in the application of certain materials to the manufacture of textile fabrics.—May 7.

George Robbins, of Forrest Lodge, Southampton, gentleman, for improvements in the construction of railway carriages.—May 7.

John Youil, of Ardwich, Manchester, brewer, for certain improvements in machinery or apparatus for washing, cleansing, filling, and corking bottles and other vessels.—May 8.

William Edward Newton, of Chancery-lane, civil engineer, for improvements in warming and ventilating buildings. (A communication.)—May 22.

Robert Cotgreave, of Eccleston, Chester, farmer, for certain improvements in machinery or apparatus to be used in draining land.—May 22.

Henry Columbus Heurry, of Manchester, civil engineer, for certain improvements in the method of lubricating machinery.—May 22.

William Palmer, of Cottage-grove, Bow-road, Middlesex, gentleman, for improvements in the manufacture of candles and candle-wicks, and in the machinery applicable to such matters.—May 22.

Jules Frederick Maillard Dumeste, of Paris, for certain improvements in reflectors for luminaries.—May 22.

Simon Pincoffs, of Manchester, Lancaster, merchant, for certain improvements in the ageing process in calico printing and dyeing, which improvements are also applicable to other processes in calico printing and dyeing.—May 23.

GREAT EXHIBITION OF INDUSTRY OF ALL NATIONS.

(*With an Engraving, Plate* VIII.)

In our last number we gave a short reference to the various designs sent in for the Exhibition Building in 1851; in our present we give an engraving, showing the plan proposed by the Building Committee, as the result of their investigations. It will be satisfactory to many of the competitors to find that the design of the Committee is formed on the same system as their own. One grand view is given through the building, from east to west, by an avenue under the highest roof, and which will be appropriated for seats, so that the visitors can scarcely fail to have their attention called to the *coup d'œil.* The general arrangements are good, but a grand dome is provided, on which we have more to say.

Besides the central avenue, a corridor of communication is provided around the building, and the spaces covered with trees are appropriated as refreshment courts, likewise serving as centres of transit, so as to facilitate access to the several departments. The entrances are four in number—the outlets all around the building. The elevations are sufficiently effective, without any attempt at display.

The iron dome, two hundred feet in diameter, or cone, as it is likewise suggested, is made the chief feature, but we question very much the expediency of the suggestion. Undoubtedly, it would be a great triumph of English art, to erect such a work; but we cannot help looking to circumstances, the more particularly when no such exertion is needed, as the contents of the building will be a sufficient demonstration of our powers and resources. It is better to rely on the book than on the binding—on the jewels than on the case—on the exhibition than on the building. The *spectacle* should consist in the objects shown, and we should not give in to the false taste of seeking to make the building itself a *spectacle.* In St. Petersburgh and in Paris, such an auxiliary as a colossal dome might be required; but we need no such *éclat.* The ocean steamer, which conveys the distant visitor—the railways, which bring him within the metropolis—the bridges which span the river—will strike him with wonder enough, and give him a full conviction of our engineering and constructive power. As a matter of taste the dome is not wanted; we think we have given sufficient reasons why it is not wanted as an object of display. Use it has none; for appropriated to works of sculpture, the most colossal bronze we have—even the Wellington statue, if brought across the road, will seem a pigmy under the vast vault.

While there is, in our humble judgment, no reason for making the attempt, we question very much whether the attempt to construct such a dome by the spring of next year will be successful, great as are our resources. A failure will injure us in the eyes of foreigners; success cannot win from them a higher opinion of our skill, while whatever the funds at the disposal of the Commissioners, there are so many urgent demands upon them as to render the outlay for a dome very undesirable.

Although all the details of the lighting are not given, there is sufficient in the plan and elevation to show that top-lighting by skylights is extensively used, which, for most objects of exhibition, is far from being favourable. A skylight gives the very worst light for most ornamental objects; and as the Exhibition will be held in the summer months, when sun light and heat are strongest, many delicate works must be very much injured, although a great expense must be gone to for blinds. We think it very desirable that side lights should be put in above the gutters in the central roof, and likewise, as far as possible, in the refreshment courts, and on the outside of the building. We are well aware there is an objection to have openings in the walls, which might give facilities for the removal of goods; but in a building so well guarded we consider this of little weight.

An arrangement, which we likewise consider as affording insufficient accommodation, is the height of the walling, which being 25 feet, is not enough for the display of carpeting and other goods of extensive area. The height ought to be at least 40 feet.

The building will certainly be vast in its proportions—beyond anything which we have seen in London; for its length is about 2325 feet, whereas the Houses of Parliament have a façade of 875 feet, London Bridge of 1005 feet, and Waterloo Bridge of 1326 feet. Thus the façade of the Exhibition Building is above twice the length of London Bridge, and thrice that of the Houses of Parliament. The breadth of the Exhibition Building being about 450 feet, and the area 1,000,000 square feet, the space roofed is far greater than the area of Lincoln's-inn-Fields, or of the great Pyramid of Gizeh. Never before was there a building so vast got up for a like purpose; for the dimensions of the Paris Exposition, as shown in the engraving in the December number of the *Civil Engineer and Architect's Journal,* are 800 feet long, and 330 feet wide, constituting an area of 261,000 square feet. Thus the London Exposition will have a façade thrice the length, and an area four times greater.

The area of 1,000,000 feet will be covered with one roof, except at the dome and the small refreshment courts; and the least height of this roofing will be 24 feet high, the greatest 50 feet. The spans will be 48 feet, except at the centre, where it will be 96 feet over the line of seats. Not only will there be a vast roof, but likewise a vast flooring, formed of boarding, laid on joists and sleeper walls.

We are glad to see that, notwithstanding the invitations of foreign architects and the compliments paid to them, the design and construction of the building adopted is to be under English auspices.

LECTURES ON THE HISTORY OF ARCHITECTURE;

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture VII.—ATHENS: *Fortifications—Temples.*

In contemplating Attica, the first sensation must be that of wonder that a spot of earth so minute as scarcely to be perceptible on the chart of the world, should have exerted so great an influence over the whole civilised globe—an influence felt in thought, in speech, and above all, in art, even to the present day. There is something sublime in the idea of a small state, naturally barren and comparatively poor, solely by the moral and intellectual energy of its inhabitants, rising like a giant to stretch its mighty shadow over all ages and all lands. Athens itself is surrounded by a halo of bright associations,—the Αστυ, one of the eyes of Greece—the learned city—the school of the world.

Great nations have risen, have conquered, and have passed away, leaving scarcely a ripple on the ocean of time—for their's was but physical power, and by nature finite; but the thoughts of great men and the works of genius, like the immortal soul from which they emanate, live for ever, to gladden the hearts of unborn generations.

While Thessaly and Arcadia boasted their rich woods and plains, the mountainous district of Attica afforded but a scanty support for a few shrubs and a thin vegetation; and in many parts the bare calcareous rock, rising above the soil, defied altogether the hand of the husbandman. But this sterility proved a boon instead of a curse: all the activity and courage of the inhabitants was called forth by necessity, that first great practical teacher. The Athenians were driven to undergo danger and difficulty abroad, in order to supply the wants of home: instead of being cooped-up within the limits of a narrow sphere, they acquired a love for enterprise and adventure; thus, at the earliest period of their history, attaining that ardour and energy of character that produced their after-greatness. Another influence was equally felt by the Athenian. The barren country of Attica had offered few inducements to the invader: the people imagined themselves its indigenous inhabitants, and were accustomed to weave golden grasshoppers in their hair to denote that they also were children of the soil. This belief gave them a passionate attachment to their native land—to those hills and plains on which no proud conqueror had ever set his foot. This patriotism—this strong love of country—prevented that overweening selfishness, always so great a barrier to progress, and brought the wanderer in search of learning, wealth, or fame, home, to enrich his beloved Athens with his accumulated treasure.

The original city of Athens was limited to the Acropolis, then called Cecropia, after its supposed founder, Cecrops, who lived about the same time with Moses. He was succeeded by a long line of kings, the most memorable of whom was Theseus. This hero is said to have given new laws to the country, and to have founded the Prytaneum as a court of justice for the whole of Attica. He also established the Panathenaic festival; and, by these means, attracted a great concourse to Athens, which thenceforward became the capital of Attica, about 1300 B.C. At the death of Codrus (1091 B.C.) monarchy was abolished, and popular freedom gained ground, until in the year 684 B.C. a democracy was firmly established, the

head of the state being a magistrate, chosen annually, under the name of archon.

From this time Athenian power steadily increased. Solon and Pisistratus flourished at the same period (between 500 and 600 B.C.); and though differing widely in other respects, they both agreed in honouring the arts and sciences. Solon, by his laws, encouraged the fine arts, whilst Lycurgus, on the contrary, forbade their cultivation; thus it was (as an ancient writer observes) that Lacedæmon has left no sign of its greatness, while Athens, from the aspect of its ruined city, would appear to have had more power than it in reality possessed.

Pisistratus founded a public library, and adorned the city with other buildings. Before the time of the Persian invasion under Xerxes, the yearly revenue of Attica did not exceed 130 talents, or 300,000*l.*; but the event which threatened its destruction was, in reality, a source of wealth and greatness. Attica, by its geographical position, was peculiarly adapted for a maritime country; its statesmen therefore turned their chief attention to the organisation of a fleet; and it was principally by the Athenian navy that the battle of Salamis was won, Xerxes driven from the country, and the supremacy gained over the other states of Greece.

Athens had been laid waste by the Persians, but rose, like a phœnix, from its ashes. Riches poured into the treasury from the spoils of enemies and the contributions of allies, a tithe was set apart for the restoration of the city, and the excitement of the people, so lately engaged in a struggle for existence, found a vent in the rapid progress of the public works.

It was during this period of fifty years, from the defeat of the Persians to the commencement of the Peloponnesian war, that the most splendid edifices were erected, under the several administrations of Themistocles, Cimon, and Pericles, and that the arts arrived at their highest point of perfection.

The first of these great men, after the devastations of war, naturally turned his attention to works of utility, commencing the long walls between Athens and the Piræeus, and fortifying the ports. The magnificence and liberality of Cimon rendered him desirous of adorning as well as strengthening the city; and though at this time (465 B.C.) the common treasury was transferred from Delos to Athens, such was the munificence of Cimon, that many of the works were carried on at his own private expense. Under his administration the Temple of Theseus and the portico, called Pœcile, were erected, the Academy and public gardens laid out and planted, and the great Dionysaic theatre commenced. The brightest era of Athens had now arrived, and at the same time a statesman arose, fitted above all others, by his cultivation of mind, taste, and eloquence, for the advancement of his great object, the prosperity and splendour of his native city.

It was the good fortune of Pericles, that in his time, artists existed capable of carrying out his ideas; and it was also the good fortune of Phidias, Ictinus, Myron, and Polycletus, to have been employed by one so fully able to appreciate their genius. Thus, in the course of a few years, were accomplished works which have been the wonder of ages; works not only magnificent in design and exquisite in execution, but erected with such attention to durability, that after the expiration of a thousand years, they were ruined by the wantonness of man rather than by the finger of time.

Plutarch observes, speaking of the buildings of this period, "A bloom is diffused over them, which preserves their aspect untarnished by time, as if they were animated with a spirit of perpetual youth and unfading elegance." The enemies of Pericles accused him of lavishing the money of the allies in gilding the city of Athens, and ornamenting it with statues and temples, as a vain woman decks herself with jewels. To this Pericles replied, that, "as the state was provided with all the necessaries of war, its superfluous wealth should be expended upon such works as, when executed, would be eternal monuments of its glory, and which, during its execution, would diffuse universal plenty: for as it was requisite to appropriate so many kinds of labour, and such a variety of instruments and materials to these undertakings, to exert every art, and employ every hand, almost the whole city would be in pay, and be at the same time adorned and supported by itself." Pericles demanded of the people, "whether or not they thought that he had expended too much?" They answered in the affirmative. "Then be it," said he, "charged to my account, not yours; only let the new edifices be inscribed with my name, not with that of the people of Athens." The Athenians however would not agree to this, and answered, "that he might spend as much as he pleased of the public treasure, without sparing it in the least."

Pericles might probably have embellished the city to a still greater extent had peace continued, but in 431 B.C. the Peloponnesian war broke out, which, lasting twenty-seven years, demanded all the resources and energies of the Athenians. In the time of Conon (400 B.C.) Athens for a time recovered her supremacy; the Dionysaic theatre was now completed, a gymnasium constructed in the Lyceium, and a stadium for the celebration of the Panathenaic games.

But a power was soon to arise before which all others had to bow. Alexander the Great was born 355 B.C., and from his time may be dated the loss of the freedom of Greece. With the loss of liberty, the love of glory that animated her people declined; that sublimity of spirit which had distinguished her artists was gone, and the arts languished in decay. Athens nominally preserved her independence by an alliance with Macedonia, but her archon was supported by a Macedonian garrison. From this time, sometimes in alliance with Macedonia, sometimes with Rome, she was plundered by both. But though her naval and military power was broken, and the brilliance of her schools of art and philosophy dimmed, she was still regarded with a kind of reverential awe; and the education of a young Roman patrician was thought incomplete unless he had studied in the schools of Athens.

Though Greece did not become a Roman province till the time of the Emperor Vespasian (69 A.D.) she had long been beholden to foreign powers for any public works that were carried on, and Greek art may at this time be said to be lost in that of Rome.

I will now endeavour to trace the position of the principal buildings of ancient Athens, that some idea may be formed of the appearance and arrangement of this once beautiful city. Nearly in the centre of the town rises the Acropolis, a craggy, abrupt, limestone rock, seemingly formed by nature for a citadel. It is oblong in form, lying from east to west, about 150 feet in height, rather more than 900 feet in length, and 480 feet in breadth. High up the sloping road to the west stands the great Propylea, which, with its wings, occupies the whole natural entrance to the Acropolis. Before the southern wing stands the small Ionic Temple of Victory, without wings, on which Ægeus stood to watch for the return of his son Theseus from Crete, and whence he cast himself in despair when the black sail appeared in sight. The Acropolis was holy ground; no dog or goat was allowed to enter its sacred precincts. Here were found the works of Phidias and Praxiteles, of Polycletus and Alcamenes, representing the gods and heroes of Athens. Wherever the eye turned, some sacred object presented itself—some form of beauty caused the footstep to linger. So numerous were the decorations of the Acropolis, that Pliny mentions no less than 3000 statues as standing there in his time.

On the highest point of ground is the Parthenon, the great temple of the tutelary goddess; and on the northern side the Erechtheion invites the devout to offer sacrifices to Minerva Polias, and the nymph Pandrossus. On the other side rose the colossal brazen statue of Minerva, the glittering point of whose spear was visible as far off as Sunium. Below, on the southern side of the rock, are the long ranges of seats belonging to the great Theatre of Bacchus and the Odeion of Regillæ. These were connected by the Eumenic Stoa. Next, towards the east, was the Odeion of Pericles, still within the Temenos of Bacchus. The street of Tripods extends from here to the Prytaneium, under the north-east angle of the rock.

Standing at the entrance of the Propylea, and looking towards the west, the first object only separated by a narrow gorge, is the hill of the ancient court of Areopagus. In the eastern corner, overshadowed by dark trees, stands the Temple of the Furies, those fearful goddesses whom no Greek could mention without a shudder, and who caused even the spoiler Nero to turn trembling away from Athens, as the place of their abode. Yonder is the Pnyx, with its rough hewn walls, and bema, or pulpit, from which Demosthenes used to address his excited audience; and beyond again stretched the Long Walls, onwards to the bustling port Piræeus, crowded with shipping and merchandise. Afar off to the north-west, is visible the sacred city of Eleusis, with its temples and propylea; the holy gate Dipylum standing between the outer and inner Ceramicus, leads to the Eleusinian road. The Ceramicus was planted with groves, and adorned with porticoes and statues. The old Agora occupied part of the inner suburb; and in this were streets, taking their name from the different trades carried on there, as the street of the makers of Mercuries, the street of cabinet-makers, &c. Beyond the gate Dipylum, at the extremity of the outer Ceramicus, was the Academy, celebrated for its grove of tall plane trees, beneath the shade of which Plato taught. Within the suburb, a little to the north, stands the Temple of Theseus; and

between this and the Prytaneium was the new Agora, and the tower or horologia of Andronicus Cyrrhestes.

Let us now turn to the south-east, where the Ilissus flows past the city, and where the Calhirroë springs, the only natural fountain of sweet water in Athens. On an island, formed by the Ilissus, stood the Eleusinium, a building so sacred, that when the inhabitants of Attica crowded within the fortifications of Athens, on the breaking out of the Peloponnesian war, the Acropolis and the Eleusinium were the only places they scrupled to inhabit. In this temple the lesser mysteries were celebrated.

On the northern bank of the river is seen the great peribolus and Temple of Jupiter Olympius; and, on the south, the stadium appropriated to the Panathenaic games. Following the course of the Ilissus we reach the Lyceium, the school of Aristotle and his peripatetic disciples; and at the foot of Mount Anchesmus was the Cynosarges, the sacred grove of Hercules, where Antisthenes founded the school of cynic philosophers. On all sides without the city gates were cemeteries and monuments; and beyond, over the country, spread the different demi, or districts studded with villas, and planted with olive groves and vineyards.

Nor were the Athenians unmindful of the poor; for we are told that there were no less than 300 places where the destitute might find warmth and shelter for the night.

To return to the Acropolis and its fortifications. The walls of the citadel show traces of various periods, some parts being composed of those unhewn blocks known as Cyclopean; others of accurately fitted polygonal blocks; and others, near the entrance, show a later style, the stones being placed in regular courses, with the joints broken as in modern masonry. The polygonal masonry appears to have been the work of the Pelasgians, who were sent for to fortify the citadel, as being the best military architects; and a space of ground below the northern side of the wall, allotted for their residence, was called the Pelasgicon.

Shortly, however, the Athenians became jealous of their assistants; the Pelasgians were driven from the country, and it was ordained that the Pelasgicon should in future lie waste, for the better protection of the citadel. After the destruction of the city by the Persians, the walls of the Acropolis were repaired so hastily that the ruins of the old buildings were used in its construction. Many architectural fragments may yet be seen in different parts. The walls enclosing the city were about 7½ miles in circuit; they were 60 feet in height, and were composed of massive rectangular blocks of stone, fastened together with iron cramps, run in with lead. This manner of fastening the blocks was very common in Greece, where cement was seldom used. The stones are now frequently found bored with holes, made for the purpose of abstracting the metal.

A beautiful example of Greek masonry exists in the pavement of the Propylea at Eleusis. It consists of blocks of Pentelic marble, 6 feet in length and breadth, and 13 inches thick, so exquisitely fitted that the joints are in many places imperceptible.

In the time of Themistocles, in order to prevent the enemy from cutting-off the communication between Athens and the Piræeus, the celebrated Long Walls were commenced, 475 B.C.: they were continued by Cimon, and finished by Pericles. These walls, including the city, and extending in a double line thence to the ports, and nearly encircling the Munychian Peninsula, were about 19 miles in length, and were flanked at intervals by towers. Where the ground was marshy, the foundations were laid with chalk and large blocks of stone; and upon these the walls were raised, so wide that two loaded wagons could pass on the summit. They were in part overthrown by the Lacedæmonians, after the Peloponnesian war, but rebuilt by Conon, after an interval of ten years, and were finally destroyed by Scylla (86 B.C.)

Of the three ports of Athens, Phalerum, Munychis, and Piræeus, which once vied in dignity with the city itself, few ruins remain; the ease with which statues and fragments could be carried away, rendering them a tempting prey to the spoiler. The sites of several buildings may yet be traced, as that of the Piræic theatre and the Agora, called Hippodamia, after the architect Hippodamus.

Many splendid structures are described as existing at Phalerum, the most ancient port. Amongst the rest, the altar inscribed "to the unknown gods;" but all these have long since disappeared.

The Spartans pursued an opposite course to the Athenians. It was the policy of Lycurgus to dissuade them from fortifying their city, preferring that they should trust to their own bravery as the best means of defence. It is to be observed, however, that the whole country of Lacedæmon is naturally fortified by the steep mountains that surround it.

The most interesting example of ancient fortification now remaining is the wall of Messene, built from the plans and under the superintendence of Epimanondas, after the defeat of the Lacedæmonians at Leuctra (371 B.C.)

The kind of masonry with which these walls are composed was called *empleeton*, having faces of rectangular stone blocks in regular courses, filled-in with rubble work. The two faces of the wall are bound together by transverse courses, or through stones, placed from 7 to 10 feet distant.

Towers were erected at intervals along the wall, of rectangular form, with the exception of two on the north-east side, the fronts of which are semicircular. The towers consist of two stories, with windows and embrasures in each. In the lower story they were splayed to facilitate the discharge of missiles. Flights of steps led to the top of the wall and to the towers from the interior of the city. One of the gates was double, enclosing a circular court 63 feet diameter. There was also an outer area 31 feet in breadth, defended by the projecting walls. On the paved road leading from the inner gateway into the city, the marks of wheels are still visible.

The walls of Pharsalia are similarly constructed, and are 15½ feet in thickness.

The ancients bearing the shield on the left arm, the right side was comparatively unprotected. This influenced the Greek mode of fortification in the plan of the approaches and the position of the towers. If an enemy were climbing the road leading to the entrance of the Acropolis of Athens, their right side would be exposed to the defenders during the whole ascent.

The masonry principally employed by the Greeks was either the before-mentioned empleeton, the isodomon, in which the courses are of equal height, or the pseudo-isodomon, where the courses differ both in height and in the length of the stones. The roads were paved with oblong blocks of stone.

Greece is remarkably rich in stone and marble. In Attica alone are the quarries of white Megarian, the grey stone of Eleusis, the bluish Hymettian, the veined Carystian, and above all, the snowy marble of mount Pentelicus. The buildings of the age of Pericles are all constructed with Pentelic marble, which, on account of its white and glittering surface, was, for architectural purposes, preferred to the more creamy Parian. Time, however, has brought their comparative excellencies and defects to light: while the Parian hardens with age, and presents a beautiful and wax-like surface, the Pentelic is apt to decompose, from being traversed by veins of extraneous matter. Works executed in this marble are now, therefore, somewhat rough and earthy in appearance.

Dr. Clarke gives an interesting account of his visit to the quarries of Paros. He says: "We seemed to view the grotto exactly according to the state in which it had been left by the ancients. All the cavities, cut with the greatest nicety, showed to us, by the sharpness of their edges, the number and size of every mass of Parian marble which had been removed for the sculptors of ancient Greece. If the stone had possessed the softness of potter's clay, and had been cut by wires, it could not have been separated with greater nicety, evenness, and economy. The most evident care was everywhere displayed, that there should be no waste of this precious marble." The following anecdote may give some idea of the value of marble amongst the ancients:—When the Ephesians were about to erect a temple to Diana, they met to consult upon the best means of procuring material; the quarries then worked were far off, and the cost of transport would have been enormous. While they were deliberating, a shepherd of the name of Pyxodorus happened to be feeding his flock on Mount Pion, or Prion, near the city; and two rams beginning to fight, one of them missing his aim, struck his horn against the rock and broke off a fragment, which proved to be of the purest white marble. The shepherd immediately ran with it into the city, where it was received with acclamations of delight. Pyxodorus was in consequence, not only honoured, but canonised, his name being changed by the grateful Ephesians to Euangelus, 'the good messenger.'" A monthly sacrifice was offered to his memory, on the spot where the discovery was made; and this custom continued to the time of Augustus Cæsar.

After providing for the defence of his city, the next care of the devout Greek was to erect fitting temples to the gods.

The pious Athenian believed himself under the protection of some particular divinity, in every event and circumstance of life. Each profession and employment had its tutelary god. The sailor sacrificed to Neptune and Amphitrite; the student to Apollo and the Muses; the artist to Minerva; and the hunter to Diana. The Temple of Bacchus was situated near the theatre,

where that festive god presided. That of Ceres was in the open plains, where the husbandman might pursue his daily toil under her protecting influence. Every fountain had its attendant nymph, and every grove its dryades, who were propitiated by offerings of milk, oil, and honey.

After the successful termination of any enterprise, gratitude was expressed to the favouring god by votive offerings, the warrior presenting shields and armour; the agriculturist his first fruits; and each worshipper according to his ability and avocation. These offering were sometimes of great value, and were preserved in t e temple, or the sacred inclosure.

In nothing did the Greeks display their sense of beauty and love of the picturesque more than in the choice of a site for their temples. They were generally placed on elevated ground, where they could be seen from afar, as the Parthenon, and those of Jupiter Panhellenius at Ægina, and Minerva at Sunium. Where this was not the case, they were separated from the noise and bustle of the city by their peribolus, or sacred inclosure, which was adorned with statues and altars, and planted with trees; thus inviting meditation by the charm of repose. In some instances the peribolus, or temenos, was so extensive as to contain other inferior temples, and even theatres and porticoes; as the groves of Jupiter at Olympia, and of Æsculapius at Epidaurus. The peribolus was frequently surrounded by a peristyle, and contained the dwellings of the priests, and all those employed in the service of the temple. These, with their families, formed a village within the peribolus, and lived, as it were, under the immediate protection of the divinity.

The Greek temples were rectangular in form. A few ruins of circular buildings have been found, called by the Greeks "tholi;" but it appears uncertain whether these were sacred structures. The temple was raised above the level of the peribolus by a platform or stylobate; sometimes this was ascended by steps only in the front; but where there was a peristyle the steps of the stylobate were continued all round. Vitruvius recommends that the number should be unequal, that the level of the temple may be gained by the right foot. Three was the customary number in the Temple of Diana Propylea at Eleusis; however, there are five; and in that of Theseus at Athens, only two. This is supposed to have distinguished it as a heroum, or temple to an inferior divinity.

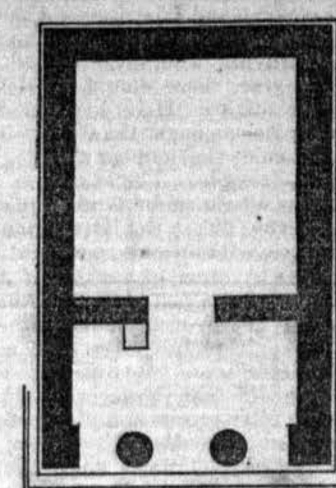
The stylobate occasionally formed a sort of area round the building. On this it was the custom to place a large altar in front of the naos, as at the Temple of Minerva at Priene, on which public sacrifices were offered, in view of the congregation assembled in the peribolus. Access to the naos or cella was prohibited to the populace; this was denoted by a cord extended across the doorway. The proportions of the temple differed according to the number of apartments required. Sometimes, in addition to the cella, there was a pronaos; sometimes both a pronaos and a posticus; and generally in the larger temples, an opisthodomos also, where the treasures and sacred utensils were kept.

Frequently, the opisthodomos of the principal temple was the public treasury of the state; this was the case at Athens, and at Delphi. The interior of the cella was lighted through the roof; or, sometimes by the door only. On the recurrence of great festivals, the whole interior of the temple was artificially illuminated.

In the earlier temples the roofs were formed of tiles, or terra-cotta, stuccoed and painted; but Byges of Naxos, who lived in the time of Solon, about 380 B.C., invented a mode of roofing in marble, for which he was honoured with an inscribed statue, a mark of distinction equivalent to a title in the present day. This invention consisted in the means adopted to prevent the water oozing through the joints of the flat marble slabs. This was done by placing over them ridges of small slabs, resembling tiles. At the extremities of each ridge, antifixæ were placed, generally in the palmette form. Below the antifixæ was a channel for the water, which passed off through the perforated lions' heads on the crowning member of the cornice.

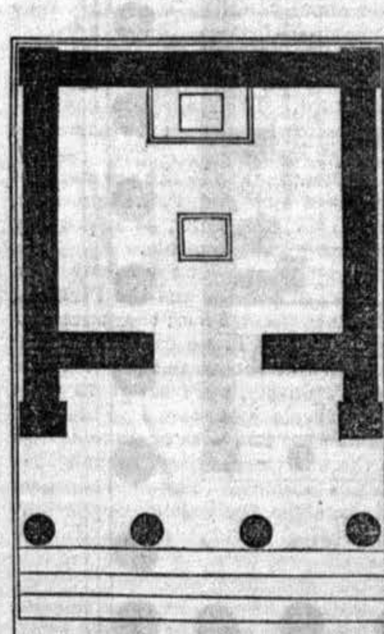
Vitruvius directs that the lions' heads over the columns should alone be perforated, while the intervening ones are left solid, to avoid the inconvenience of water dripping upon persons entering the peristyle.

Greek temples are divided by Vitruvius into seven classes, which he denominates *in antis*, *prostyle*, *amphiprostyle*, *peripteral*, *dipteral*, *pseudo-dipteral*, and *hypæthral*; though few of the Greek examples exactly agree with the rules laid down by Vitruvius, they bear a sufficiently close resemblance to be thus classified. The temple *in antis* (or as the Greeks termed it, *naos en parastasin*) is the most simple, consisting merely of a cella, the walls of which are terminated in front by antæ, or pilasters, between which two columns are placed, supporting the entablature; the whole is crowned by a pediment.

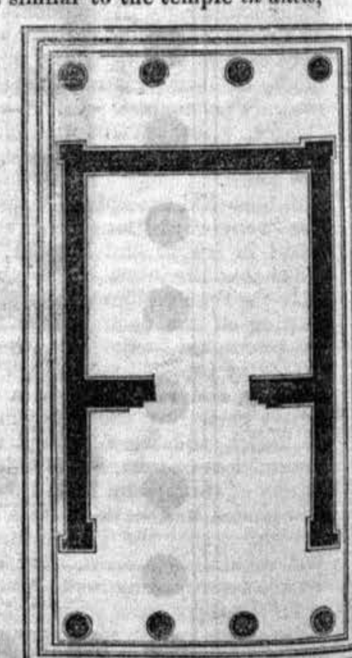


Temple in Antis—Themis at Rhamnus.

A beautiful example of an Ionic temple *in antis* was found in Asia Minor, a drawing of which is given in the 'Ionian Antiquities,' published by the Dilettanti Society. There is also an ancient example at Rhamnus in Attica, called the Temple of Themis; this is constructed with polygonal blocks of marble, and is of the Doric order; it is only 35 feet in length by 25 feet in breadth. A variety of this class is seen in the Temple of Diana Propylea at Eleusis, in which the form of the front is repeated in the rear, thus being to the simple temple *in antis* what the amphiprostyle is to the prostyle. In the Temple of Esculapius at Agrigentum, there are two engaged columns between the antæ in the rear. The great Temple of Ceres at Eleusis was *in antis* until the time of Demetrius (307 B.C.), when the architect Philo added to it a magnificent dodecastyle portico, thus bringing it under the second class, the prostyle. This was similar to the temple *in antis*,



Prostyle Temple at Selinunte.

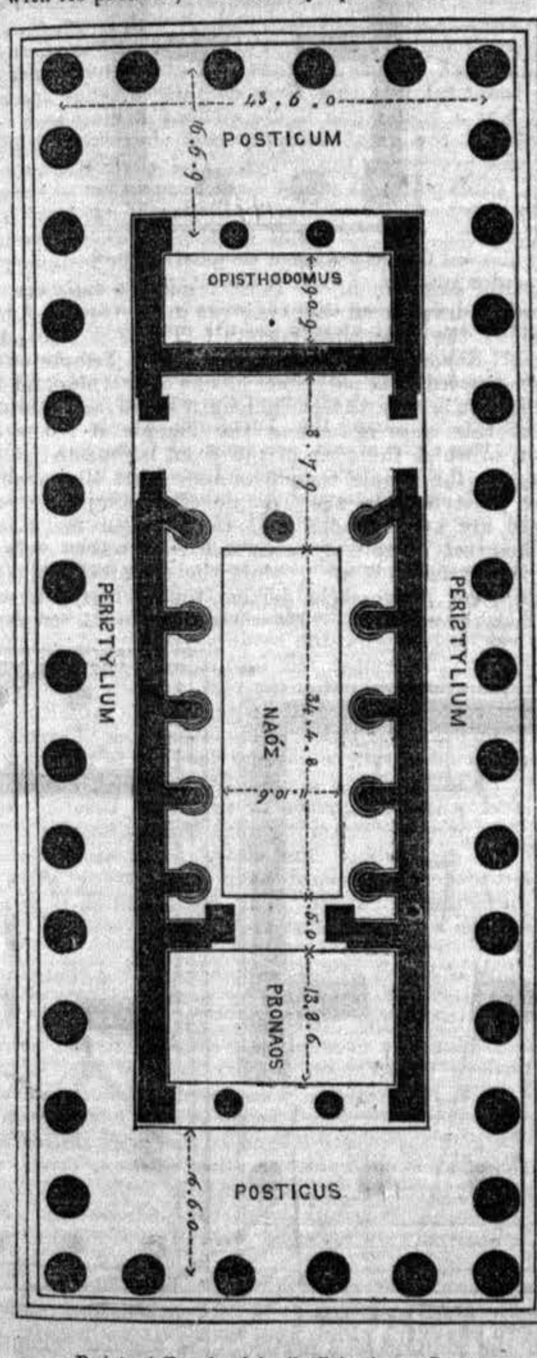


Amphiprostyle Temple on the Ilissus.

only with the addition of a portico; the angular columns of the portico are placed in front of the antæ, terminating the wall; in this class a pronaos, or vestibule, was sometimes added to the cella.

The amphiprostyle temples have a portico in the rear, as well as one in the front; this posticus is generally added when a second entrance is required. An example of this class is the Ionic temple on the Ilissus, a restoration of which is given in Stuart's 'Athens.' The larger Greek temples are mostly peripteral; that is, they have an ambulatory or peristyle along the flank, as well as porticoes in front and rear. Of this class is the Temple of Theseus at Athens, now in better preservation than any building of ancient Greece.

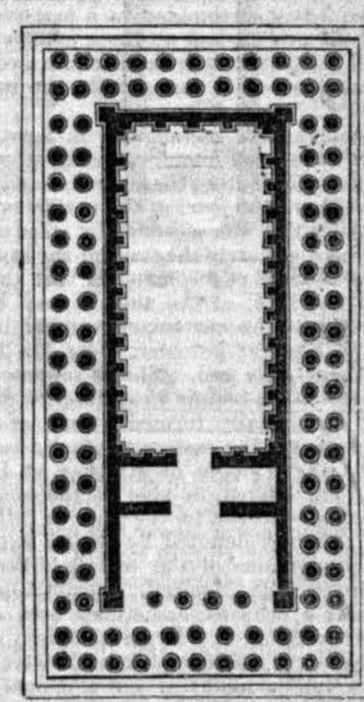
In the year 465 B.C., after the battle of Marathon, Cimon had the remains of Theseus conveyed to Athens, where they were reinterred with great pomp and rejoicing, and this beautiful edifice erected over the place of sepulture. It is hexastyle, but differs from the rule of Vitruvius, who says that where there are six columns in front and rear, there should be eleven in the flanks, including those at the angles. Here, however, there are thirteen columns in the flanks; nor amongst the Greeks does there seem to have been any fixed rule, the number differing according to the required length of the temple. The hexastyle Temple of Apollo Epicurius at Bassæ has fifteen columns along each flank, and that of Bacchus at Teos eleven; but in the latter temple there is merely a cella, with its pronaos, without any apartment in the rear.



Peripteral Temple of Apollo Epicurius, at Bassæ.

The Heroum of Theseus has a cella, with a pronaos and posticus, formed by the prolongation of the side walls of the cella. The cella is 40 feet in length, by 23 feet in breadth; the pronaos, with its portico, is 33 feet; and the posticus 27 feet in depth. The columns are 3 ft. 3·65 in. lower diameter, and 18 ft. 8·6 in. in height; the intercolumniations of the peristyle are 5 ft. 4 in., and the width of the ambulatory 6 feet. The whole height of the temple to the top of the pediment is 33½ feet. The Greeks, in a great measure, overcame the effect of the small space between the portico and the pronaos, and the posticus and the opisthodomus, by making the interior columns of smaller dimensions; thus calling in the delusion of perspective to their aid. The interior of the temple also was raised a step from the portico. The eastern portico only of the Temple of Theseus was adorned with sculpture. The metopæ were carved in bas-relief, the subjects taken from the principal events in the life of the hero, and the walls of the cella were decorated with historical paintings by the hand of Mycon. This temple was surrounded by a peribolus, of such extent that the military assemblies were held within it. It was also an asylum, or sanctuary, and is now a place of interment for those of our countrymen who die at Athens.

During the last year of Turkish dominion in Greece, the Pasha having been informed that a hive of bees had settled in the north-eastern corner of the pediment of the Temple of Theseus, ordered his people to bring him the honeycomb. Upon being told that it could not be got at, as it was so far down among the stones, he commanded the corner of the pediment to be thrown down, in order that the honey might be obtained. Such anecdotes should be considered by those who blame the English for having carried away the relics of ancient Greek art—these "robberies," as some have been pleased to call them, having been the only means of preserving them from total destruction.



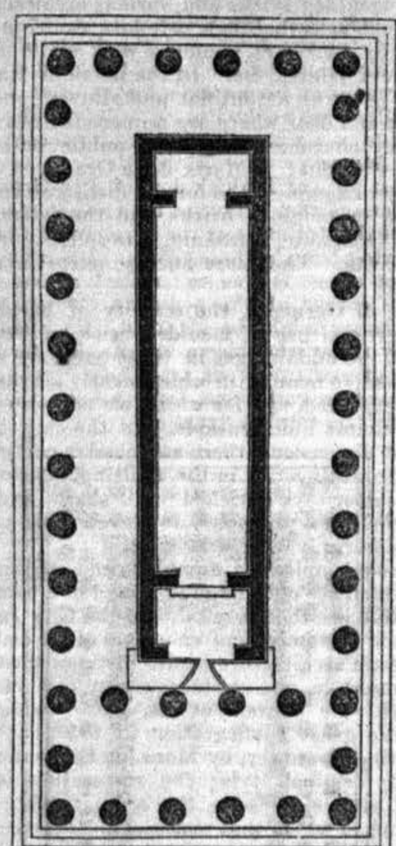
Dipteral Temple of Apollo Didymæus, at Miletus.

The fifth class, the dipteral temples, have two rows of columns along the flanks, forming a double ambulatory. The Temple of Diana at Ephesus, built by Ctesiphon, and that of Apollo Didymæus at Miletus, were dipteral. Finding the number of columns both inconvenient and expensive, Hermogenes of Alabanda omitted the interior range of columns in the peristyle, making the walls of the cella range with the columns third in order from the angles of the front, and giving an ambulatory of double width,—thus inventing that class known as pseudo-dipteral. The great temple at Pæstum, that of Diana at Magnesia, one at Selinunte, and many others, were constructed on this plan.

Vitruvius describes the hypæthral temples as belonging to a different class; but this distinction does not appear to have existed in Greek temples; all those, whether peripteral, dipteral, or pseudo-dipteral, dedicated to the principal divinities, being hypæthral, or having the cella open to the sky. This custom originated in the east, and was continued amongst the Greeks, it being deemed impious to confine the deity within a temple covered in by mortal hands, instead of by the blue canopy of heaven. To exclude the sun's rays, or to protect the statue placed in the cella from the inclemency of the weather, a peplus, or veil, was either extended over the opening in the roof, or suspended before the statue. The peplus is mentioned in a passage of Euripides:—

"Then from the treas'ry of the god he takes
The consecrated tap'stry, splendid woof!
To clothe with grateful shade the wondrous scene,
First o'er the roof he spreads the skirted peplus."

The preparation of the sacred peplus, which was richly embroidered, was committed to a band of chosen virgins. At Athens, a new peplus was presented to Himeron, at the recurrence of the great Panathenaic festival, every five years.



Pseudo-dipteral Temple at Selinunte.

It at first excites surprise that in countries so limited as Greece and her colonies in Asia Minor, so many magnificent temples should have been erected, regardless of labour and expense, and that some of the most splendid sacred edifices existed in otherwise insignificant cities; but it must be remembered that many of these were cathedral or amphictyonic temples, where people of different states and towns assembled at certain times to celebrate festivals, hear causes argued, and settle disputes; and all thought it a honour to be allowed to contribute to the adornment of the holy edifices. Such were the Temples of Diana at Ephesus (in renewing which Alexander the Great in vain offered to defray the whole expenditure to be permitted to have his name inscribed there) and of Apollo at Delos, where the Ionians were accustomed to congregate at a periodical festival; and where Apollo was worshipped under the ancient form as Mithra; the capitals of the columns being formed each by the busts of two kneeling bulls, side by side, the old symbol of sun or fire worship (an engraving of which is given in the supplementary volume of Stuart's 'Athens'). Such too was the great Temple of Jupiter at Olympia, which was crowded with worshippers from all the Hellenic states every fifth year to celebrate the far-famed Olympic games, to be victorious in which was considered supreme felicity. The Temple of Jupiter was more ancient than the Parthenon, dating, according to Pausanias, as far back as 650 B.C.; but it must have been restored or repaired after that time, as the roof is said to have been constructed on the plan of Byges of Naxos. This temple was of the Doric order, peripteral and hypæthral: 'it was 230 feet in length, 95 in breadth, and 68 in height to the summit of the pediment: it was built by Lybon of Elis. On the centre acroteria on each pediment, stood a gilt figure of Victory, with a golden shield beneath, and gilt vases were placed on the acroteria at the corners of the roof. According to Pausanias twenty-one shields were suspended on this temple, the spoils of Numonius, on the conquest of Achaia. The custom of hanging shields on the temples has been before remarked upon; one was placed on the Temple of Minerva at Syracuse (probably on the acroteria), which was seen far out at sea: it was the custom of the Sicilian sailors to offer sacrifices to ensure a prosperous voyage on losing sight of this shield. The chief glory of the temple at Olympia was the colossal statue of Jupiter, 60 feet in height, formed of ivory and gold: one of the masterpieces of Phidias. After the works of the Parthenon were completed, Phidias and his disciples removed to Elis to adorn the city of Olympia; he was employed here about four or five years, and was held in such high estimation that he had a studio assigned to him, close to the sacred grove, and was allowed to inscribe his name upon the footstool of the divinity. The building in which he formed the statue was long known as the workshop of Phidias. The god appeared seated upon a throne, crowned with a golden olive wreath; in his right hand he held an image of Victory, and in his left a sceptre richly inlaid and surmounted by the figure of an eagle; his robe and sandals were of gold, covered with lilies and other devices; his throne was sculptured in relief, and set with ivory, ebony, gold, and precious stones. On each foot of the throne were four dancing Victories in relief, and two statues of Victory stood near on each side. So beautiful was this Zeus considered, that according to Arrian, it was a misfortune to die without having seen it. The descendants of the great sculptor had alone the privilege of cleansing and preserving the statue. The whole territory of Elis was sacred to Jupiter; it would have been an act of the greatest impiety to carry on war within its limits; if an army marched through the state, they delivered up their arms on entering, and were only allowed to resume them on passing the boundary.

The oracular temples of Greece also attracted a great concourse of those desirous of prying into the secrets of futurity. Of these the Temple of Apollo at Delphi was the most celebrated; the first stone edifice was erected here 548 B.C., and was the great repository of the treasures of ancient Greece. Whilst Phidias was employed at Olympia, the artists of the ancient, or archaic school, were engaged in decorating the Temple of Apollo. Amongst the followers of this style of art, we hear of Canachus, Calon, and Hegesias; but as the archaic school retained the crude, stiff, traditional forms, whilst Phidias and his pupils effected a revolution in art through their earnest study of the beautiful in nature, it is not wonderful that the names alone of the former artists have descended to posterity, and those attended with but little fame.

The means by which the oracular responses were obtained at Delphi are too well known to need repetition here; but in another celebrated shrine at Argos, the mode of deception has only been discovered since the temple fell into ruins. The end where the altar stood was excavated out of the rock, and the remainder of the building constructed of baked tiles: part of this structure with the altar still remains. Dr. Clarke, in his interesting 'Travels,' relates that he found a subterranean passage leading to the back of the altar; this, he says, was so cunningly contrived, having a small aperture level with the surface of the rock, that it was easily concealed. A person descending into this passage might creep along till he got behind the altar, from whence the voice mysteriously proceeding, would have an imposing effect to the prostrate worshippers in front. The reverberation of the hollow rock would give a supernatural sound to the voice of the person concealed.

A third class of sacred edifices supported by the contributions of the assembled multitude, may here be mentioned—those dedicated to Esculapius, the divine physician. These places of resort for invalids were generally situated near some medicinal spring, and, like our Bath or Cheltenham, appear to have been as much for amusement as for restoration. The sacred grove of Epidaurus was the most celebrated, where the efficacy of the holy stream or the favour of the god was acknowledged by the presentation of numberless little effigies of limbs, or other parts affected, such as may be seen suspended around the image of some miracle-working saint in the Continental churches of the present day. Many of these at Epidaurus were attached with wax to the knees of the statue of Esculapius.

So great a similarity exists amongst the temples of ancient Greece that a detailed description of each would be mere repetition, there are two however, which from their extreme beauty, demand particular notice. I shall begin the next lecture, therefore, with an account of the Parthenon and Erechtheion at Athens; and shall then describe the theatres and other places of public amusement, concluding with the villas of the Greeks, and their mode of decorating their edifices, whether public or domestic.

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TERRACOTTA AND ARTIFICIAL STONE

Some remarks on Terracotta and Artificial Stone as connected with Architecture. By CHARLES FOWLER, V.P.—(Paper read at the Royal Institute of British Architects, June 10th, 1850.)

ALTHOUGH the subject I have to present to you is not of an attractive nature, I hope it may prove not unworthy of your attention, inasmuch as every architect must have experienced the importance of being well acquainted with the various materials which may be available according to local and other circumstances, and which require various modifications of design and construction, demanding the exercise both of his taste and skill. With this impression, I venture to invite your attention to the subject of Terra-Cotta and Artificial Stone, as materials offering valuable means of obtaining architectural effect and expression when stone or marble cannot be procured, or cannot be employed by reason of their great expense. Under the general designation of terra-cotta, in its literal sense, I include all moulded work, such as bricks formed to be substituted for stone in constructing columns, vaulting-ribs, windows, and other architectural members, as well as those parts which are more strictly ornamental, as corbels, tablets, friezes, statues, vases, &c. For these various purposes, and under an infinite variety of circumstances, we shall find that terra-cotta has been employed with good effect; giving the advantages of variety and durability, at a moderate expense, in many cases in which these objects could not be so well attained by any other means. On investigating the origin of terra-cotta, or the practice of moulding and baking clay for building purposes, we may extend our researches to the earliest times; for it is obvious that the art of forming bricks and pottery must have been one of the first efforts of civilisation; but, although such may have been its origin, our subject properly relates to superior efforts, requiring the talent of the artist as well as the skill and dexterity of the artisan.

The ancient cities of Nineveh and Babylon are considered to have been chiefly constructed of brick; but modern researches have not brought to light any specimens that come properly within the scope of our subject. No bas-reliefs, nor architectural members of any kind, in terra-cotta, have been found, but merely vast mounds, the debris of buildings serving only to identify the sites of these once renowned cities; this negative evidence, however, must not be deemed conclusive against the existence of the art in places where so many circumstances concurred to call for, and to promote its practice.

In Greece, where stone and marble abound, and were so extensively used by the ancients in their celebrated structures, we find, nevertheless, that terra-cotta was sometimes introduced—for example, in the eaves of roofs, in which use and ornament were skilfully combined, by making the crown mould of the cornice form the front of the gutter. It is evident that the roofs to which these specimens belonged were covered with tiles, of which they formed the bottom course; thus uniting the roof with the cornice belonging to both, and answering the useful purpose of an eaves gutter. It will be seen that there is considerable ingenuity in the mechanical contrivance for fixing, as well as great taste in forming this crowning member of the cornice. Campana, in his Work on Terra-Cotta, mentions ornaments among the remains of the Erectheum, which are probably similar to that already described.

Many instances might be adduced of the introduction of terra-cotta in Roman temples, but I am not aware of any specimens of the same architectural character as those just mentioned. The collection of bas-reliefs and statuettes, &c., at the British Museum, are well-known (although at present secluded in close presses.) They exhibit striking examples of the taste and skill of the ancients in this department of decorative art. Engravings of them have been published by the Trustees of the Museum, and many of them are further illustrated in a superior manner in Campana's work, from which it appears that there are duplicates of several of the specimens, and consequently that moulds must have been employed in producing them. There are also further repetitions of these specimens in the collection of the Soane Museum. It is remarkable that in every instance clay only is used of various kinds and degrees of fineness, but without any mixture of other materials, as in the modern practice of forming artificial stone. The Etruscans were so eminently distinguished by their skill and taste in the fabrication of pottery that we may naturally infer that they employed the same material in architectural decoration also in lieu of sculpture; but I am not aware of the existence of any specimens of Etruscan terra-cottas, excepting those very rude ones of tombs and monumental effigies in the British Museum. After this cursory glance at the use of terra-cotta by the ancients, we pass on to the use of it in the middle ages of which the evidences are more numerous, as the application was much more extensive.

In Romanesque buildings, and those erected in the cinque-cento period, we find moulded bricks and various architectural members of terra-cotta, such as corbellings, columns, vaulting-ribs, cornices, enriched arches to doorways, windows with mullions and tracery, medallions, tablets, friezes, &c. In the north of Italy, where the country is to so great an extent flat and alluvial, and stone is consequently scarce and dear, there are numerous instances of the use of terra-cotta in churches and other public buildings. Aggos' Tower, and the church of S. Maria delle Grazie, at Milan, may be cited among other examples; the former distinguished by elaborate details executed in moulded bricks, and the latter, in those portions erected by Bramante, containing bas-reliefs and other enrichments in terra-cotta. The more ancient parts have brick mouldings, corbels, &c.

In the north of Germany, the scarcity of building stone has led to a very general use of moulded brick and terra-cotta; and the buildings of the middle ages in these parts are remarkable for the bold and effective manner in which nearly all the architectural features are so executed, and for which we are accustomed to consider stone as almost indispensable. In the churches, which are generally of vast dimensions, there are massive columns elaborately moulded, bold projecting-ribs in the vaulting, mullions and tracery in the windows, doorways enriched with shafts and mouldings—ornamental corbellings, pinnacles, and even finials, all formed in plastic clay well burnt.

At Lubeck the examples are numerous and striking, and besides the churches, which are on a large scale and of a bold style, may be noticed the Rath-haus, the Hospital, and the City gates; the latter being surmounted by towers and chambers of an elaborate character. The domestic architecture is also distinguished by the prevalence of the same style, and produces a very picturesque effect.

At Hamburgh, the church of St. Peter, which was nearly destroyed by the great conflagration in 1842, has been entirely restored, excepting the tower, by Mons. de Chateuneuf, with strict adherence to its original style; the restoration is executed in moulded brick, and is probably the only instance of a modern work of this kind in which that material has been so extensively and efficiently employed.

At Hanover, the Rath-haus is a curious specimen of elaborate mediæval work in brick, but the style is not so general in that city as at Brandenburg, Luneburg, Tangermunde, and other towns lying more to the north and east, which are more completely within the district where brick constructions prevail, and stone is rarely met with in ancient structures. In our own country the art and practice appear to have been introduced much later, and can scarcely be traced beyond the Tudor period, when plastic materials were found particularly convenient and economical in the execution of elaborate details with extensive repetitions of the same parts, as in ornamental chimney-shafts, battlements, corbels, friezes, mouldings, pinnacles, &c. Examples of these are too numerous to be particularised, as they would form a long catalogue of ancient mansions and collegiate buildings by which the age of the Tudors is distinguished, and which have been ably illustrated by the publications of modern authors and artists.

In the parsonage house at Great Snoring the frieze consists of a series of heads in niches, in bold relief, all formed by two moulds, and closely resembling similar friezes in private dwellings at Bologna, where the same kind of ornament is found to prevail. At Hampton Court, the medallions containing Roman heads, in bold relief, inserted in the walls, appear to be of Italian workmanship, and there were several of the same description in old houses in the city of London, but the besom of modern improvement has swept away the greater part of them. The county of Norfolk is remarkable for a great number of ancient structures, in which the architectural and decorative features are wrought out in moulded brick, or terra cotta (doubtless for the local reason before alluded to) and amongst the most ancient of these may be mentioned Caister Castle, near Yarmouth (temp. Hen. VII.) whose lofty towers and bold corbellings make it assimilate with some of the ancient fortresses on the banks of the Rhine.

The style of execution which we have been considering appears to have had its full development during the Tudor period, at the latter part of which it was superseded by the introduction of Italian architecture; for examples of moulded brick work, or terra cotta, are rarely to be met with in edifices erected subsequent to the reign of James I., except as detached tablets, shields, or heraldic insignia.

It is rather remarkable that the revival of the manufacture of terra cotta, or more properly of artificial stone, in England, should have been effected by a lady. About sixty years ago, Miss Coade, from Lyme Regis, possessing a large share of scientific knowledge and energy, embarked in a small manufactory of artificial stone in Lambeth, which, by her perseverance and good management, eventually attained a considerable degree of celebrity. To this original establishment in Lambeth the merit is due of greatly improving the composition of the material, and the processes by which its permanent character was attained. The proprietor had also sufficient enterprise and discrimination to avail herself of the talents of some distinguished artists, and thus produced works of a superior character, which may fairly vie with those of the chisel. The bas-relief in the pediment over the western portico at Greenwich Hospital, representing the Death of Nelson, was designed by West, and executed by Bacon and Panzetta, who also modelled many other distinguished works.

With respect to modern instances of the use of artificial stone, St. Pancras Church may be considered as one of the most important; the greater part of the ornamental details being formed of this material, at the large outlay of 5400*l*. The work was executed by Mr. Rossi, from the designs of Mr. Inwood, the architect: and, according to present appearances, the material promises to be very durable. About the same time extensive bas-reliefs, colossal figures, and other decorations, executed in the same material, were placed on the front of the Custom House, London, but these specimens have been removed. The statue of Britannia, made of artificial stone, which crowns the Nelson column at Yarmouth, remains uninjured by the exposure, to which the stone work seems to be yielding. The Bau-Akademia, in Berlin, by Schinkel, is a remarkable example of the modern adaptation of moulded brick and terra-cotta, of which every part, even the face of the walls, is most carefully wrought and finished.

Having taken a general view of the history of the art in question, and its application in various ages and countries, it may be proper to give some account of the composition and modes of forming and perfecting the artificial stone as now practised. It has been already stated that the ancient examples are evidently formed simply of fine clay, or brick earth—carefully prepared and well burnt—and they are, therefore, precisely of the same nature as coarse pottery ware, and are correctly designated "Terra-cotta;" but the modern artificial stone is a very different substance, and greatly superior to them in hardness, texture, and colour. The result of inquiry at several establishments shows that some difference exists, both in the composition and processes adopted by the respective manufacturers, but without any obvious difference in the results. The principal ingredient is the white potter's clay, forming about one-half; pulverised stone ware from one-third to one-fifth; ditto glass, from one-fourth to one-ninth; and some add, for finer purposes, a small portion of white Ryegate sand and powdered flint, about one-tenth part of each: these ingredients are carefully mixed in a pug-mill to a stiff consistence suitable for modelling or moulding, and then worked into the various forms required. With a view to ensure perfect burning, an uniform thickness must be preserved in all parts, usually about 1½-inch, but proportionate to the bulk and strength required; considerable attention is necessary in the process of drying that it should be slow and regular, so as to avoid any distortion of form; the time to be allowed must, in some measure, be governed by the state of the atmosphere and other circumstances. The same considerations regulate the burning, which should proceed by very slow degrees to a white heat, and ample time should be allowed for cooling: the practice in these respects—which appears to vary very widely in different manufactories—allows from ten to fourteen days for drying, from seven to fourteen for burning, and three or four days for cooling.

The kiln at Messrs. W. Cubitt and Co.'s, which may be taken as an ordinary example, is a cylinder of 10ft. 6in. diameter externally, and 10 feet high to the base of the cone. The enclosing wall is two bricks thick, having a large opening for packing and unpacking the articles to be burnt. When the kiln is filled, this is closed up with lumps, preparatory to lighting the furnaces. The interior is lined with tiles ½-inch thick, grooved and tongued together, and set in Stourbridge clay, leaving a vacancy of 4 inches, which is called the muffling, all round. There are two furnaces, and about three tons of coals (Hartley's) are consumed in one burning. The progress of the burning is ascertained by looking through an inspection-hole with a lens in the side of the kiln.

Having been led to the consideration of this subject with a view to its practical application, I venture to adduce some instances in which I have used artificial stone, combined with other materials, in the construction of cornices, which, at the same time, serve the purpose of eaves gutters. The advantages proposed in these cases were lightness and strength, with durability and economy. In one example here exhibited, it will be seen that, as a mere corona of the cornice, it gives apparent magnitude to the elevation, with very slight addition of substance or weight. The material, from its hardness and imperishability, is best suited to the situation where it is most exposed to injuries. It also forms a rim, or margin, which throws back the water instead of allowing it to run down over the face of the mouldings in the usual way, in which the top slopes outwards; and by which, in a smoky atmosphere, the cornice is liable to be much defaced and injured. Another example refers to the cornice of a pediment, therefore it is independent of any gutter. In another example the gutter is at the back of the cornice, and is of a distinct construction. In another the gutter is contained within the facia and crown mould, forming a continued trough, resting on a course of slate slabs, which constitute the soffit of the cornice. And, in the last example, the gutter forms a separate portion, lapping over a facia, which is also of artificial stone; and the whole is supported on slate slabs, as the preceding one. The several parts are united lengthwise, by rebated joints, set in white lead, and bedded in cement on the brick and slate. The Greek examples, before alluded to, first led me to this practical application of terra-cotta. It should be observed, that the chief difficulty in preparing this material for the several purposes mentioned, is its liability to become distorted in drying and burning. To avoid this it is necessary that the pieces should be short in proportion to their width; and then the deflections (which in some degree are unavoidable) may be so adjusted in setting as not to be conspicuous; and as the cornice is the part most remote from inspection, the imperfection is the less observable. Further, it may be presumed, that if the use of artificial stone were more general, and occasioned consequently a greater demand for this description of work, some means would no doubt be found for rendering the manufacture more perfect. In order to obtain a fall or current in the trough gutters, the bottoms are partially filled up with Portland cement having the greatest thickness towards the centre, and gradually diminished to the outlets. This, besides facilitating the discharge of the rain water, serves to strengthen the construction, by covering the joints and fortifying the sides. The colour of artificial stone assimilates tolerably well with Portland or Caen stone, but the texture is liable to have too much of the glare of pottery. Its durability, if properly manufactured, may be deemed almost unlimited, and its economy, if judiciously applied, is a further recommendation; but this involves many important considerations for the judgment and discretion of the architect.

Although these remarks have properly been limited to terra-cotta and artificial stone, which, as the designation of the first implies, have to undergo the action of fire; yet, as the latter is now applied to a material prepared by a different process, it may not be irrelevant to make some mention of it on the present occasion. It appears that this substance consists of a concrete, formed with cement and sand, variously proportioned, and the forms are produced from moulds; consequently one of its chief advantages is economy where numerous repetitions are required. If a nice finish is desired, these productions can be worked up and sharpened by the chisel.

This art has been practised for about twenty years; but it is more particularly within the last ten years that it has been brought into very extensive use: the experience, therefore, of its durability is, at present, rather limited; but, at all events, great credit is due to the manufacturers, for the taste evinced in many of their productions, which constitute another resource, in cases where the works of the sculptor would be excluded by their great expense.

Reverting to terra-cotta, I beg, in conclusion, to observe, that it may be seen from what has been stated, that it possesses many valuable qualities and recommendations when introduced with skill and discrimination—viz., strength, durability, and economy; more particularly where high relief and sharpness are required, and for parts extensively repeated. That it affords the most perfect opportunity for the development of artistic talent in the higher branches of art, inasmuch as the model in this case becomes the original and permanent work; embodying in all its freshness the original touch and conception of the artist. Further, and in regard to structural considerations, that it may be combined with other materials, so as to afford increased means and facilities for giving architectural expression with sound construction and economy.

THE POETRY OF ARCHITECTURE.

A paper read by James Edmeston, jun., *at the General Meeting of the Architectural Association, May 31st*, 1850.

If it be true that Architecture is a fine art; that it is eminently capable of receiving the marks and impressions of mind and intellect; if it has the power of reflecting the radiations of the heaven-born fire of genius—why, then, it is most truly poetical. For what is poetry but a combination of all these? and to talk of the poetry of architecture is not a mere form of unmeaning words, but expresses a fact that should attract our attention and study, since it cannot be possible for us to place the standard of our art too high, or to fix a limit to the excellencies of which it may be capable.

That architecture does possess all these characteristics, I think few will deny; and if to some, such expressions may seem to belong to mere theory, I will ask them, at all events, to allow what is, unfortunately, evident enough—that the opposite of these things exists; that is to say, that want of harmony, that bad taste, which we commonly call vulgarity, and which is the offspring of an uneducated mind and low order of imagination. If, then, it is too certain that architectural forms have the power of conveying to the mind such impressions as these, I must contend that it is absurd and impossible to say that improvement is not to be made. The mind instinctively points out what is vulgar, deformed, and unpoetic: there must of necessity be the reverse of all this, and the mind will discern and approve what is beautiful, poetic, and proportionate.

It does appear to me that more profit than may be at first sight apparent, may be derived from the study of the art under such an aspect as that now under consideration, since the desire of excellence is the incentive to all exertion; and the more fully the mind is impressed with the glorious height and perfection which may be attained, the more firmly and determinately will it buckle on the armour of thought to the task, the more intently will it labour to surmount the difficulties of the road, and gaze firmly on the goal which it desires to reach,—while without faith in the result of our exertions we can achieve nothing.

What I would call the true poetry of the art is that combination of mass, that disposition of outline, that moulding of form and arrangement of detail, which should be guided by taste the most elevated and refined, and, above all, should speak to the beholder clearly and intelligibly, with a voice mighty yet inward—a work, the contemplation of which, like the divine strains of melodious music, should elevate and purify the mind, encouraging those sensations of the soul which partake least of the earthly clay from which we have sprung, but which, with purity and intensity, yield charms to the imagination far beyond those of a grosser nature; appealing to the sensibility of the soul, and to those innate perceptions of the beautiful which God has implanted in all his intelligent creatures,—the external harmony from without, finding an internal response within us. Very mysterious and subtle are these influences of what we call "*the beautiful*," or, as I have called their highest expression, the poetry of art and nature—neither to my mind existing only in the power of perception, but an actuality in the thing perceived; not wholly a matter of the intellect (to be merely acquired like scholastic learning), though certainly to be cultivated and improved,—but partaking of all these; consisting of none wholly, but in part of all; an absolute outward principle, fact, and perfection, existing in and pervading all things, though often we may not perceive or understand it. Yet it is of great importance that we should believe it is to be achieved and evolved; for if not, we may fall into that frigid and philosophic view of our art, which will so alter its nature, that we shall no longer be able to talk of its poetry; and may at last reduce it to a mere manufacture, or to be worked out like a mathematical problem—not taught to spring into warm life by the creative power of genius, full of powerful thought, and clothed with the glowing expressions of poetry. We should, then, gladly welcome those refining influences of high art, allowing that such things may be and are, and strive to improve them to the uttermost. I have not alluded to *colour* as being a primary agent in producing these effects, because I certainly think that, although an important element and not to be despised, yet that it is certainly altogether secondary to form, arrangement, &c.

All fine art must be poetic; for is it not the illuminating power of genius, and the thoughtful ardour of a superior mind, which, working upon the natural rough and intractable material, makes of the block of unshapen stone an Apollo Belvidere, or arranges colours with true and powerful harmony on the canvas?

Perhaps it may not be an inapt simile to compare the works of the painter and sculptor to the sonnet, every word of which should contain the richest imagery and most suggestive thought, polished and refined with the greatest care, and yet brought into so small a compass; while the architect's works come more nearly to the grand, less-minutely finished, but powerful and majestic, epic—in part forcible and striking, in part subdued and general; varying in description, but as a whole, grand and complete.

Let us, however, endeavour to trace the poetical element in the old world efforts of architectural art. To begin with the half-temple, half-palace, erections of the Egyptians—the great temple of Karnac, for example; this, and most of the other productions of Egyptian art, do not, I think, bear evidence that the artist was actuated so much by higher impulses, as by the desire to produce something *grandiose* and magnificent: as if each dynasty wished to leave the page of its history indelibly written, and set up on the face of the land for succeeding ages to wonder at, rather than moved by any deep religious feeling, or any of those higher aims which would have ensured more perfect results. Wonderful, majestic, and surprising as are their works, I do not consider that they exhibit so much mental vigour as perhaps every other style, nor much elegance of mind; in fine, I think that if the Egyptians had taken a higher aim, and been actuated by higher purposes, they would then have produced, with their wonderful technical ability and resources, works of a higher stamp, and in all respects much superior: but they seem to have been wanting in imagination, and, from some circumstances of position or habit, to have been deficient to some extent in *poetical* genius—learned and scientific though they certainly were.

But leaving this era of art, and turning to the Greek—what an extraordinary difference do we find! The characteristics and purposes of the former style are quite gone (I do not mean mere evidences of relationship and descent, but of feeling and thought); and I think that it must be allowed that here the poetical element exists most strongly. In Grecian buildings we see the language of mind, earnest, determined, elevated, and poetical—a purity of thought and loftiness of idea which is the more surprising when we consider the grossness of their religious myths and other circumstances of their position. Let us suppose the Parthenon as it was first erected, fresh and unmutilated—from its vastness, imposing and arresting the attention of the beholder; with its just proportions, pleasing and delighting his eye; and with its general purity of design, refining and elevating the emotions of his soul; exciting no one thought displeasing and gross, but leaving him better and happier—he can scarcely tell you why—for having seen it. Yet the reason is no more than this, and as we have before observed, that genius and thought *can* make themselves felt and evident, and can speak to the minds of others, no matter through what medium—imparting a feeling which language can hardly express, but which the soul can well understand; even as the poet will carry away his hearers or readers by the creations of his fancy conveyed in words.

Coming next to Roman art; I think we find the poetical element much less clearly expressed. The reason I take to be, that the Romans had naturally no such soul-felt love for their art as the Greeks had; their time and attention were too much otherwise occupied; they wanted, to a great extent, that elegance of mind which the Greeks possessed; and their fondness for military pomp and grandeur, and for outward show, made itself apparent and overruling in their architecture: for to do much and largely seems rather to have been their aim than to do well thoughtfully and carefully. They seem to me much more the works of a great nation than of a refined one; and therefore, as we have argued must be the case, to possess much less poetic feeling and poetic influence, in spite of the grand proportions of a Colosseum, or the enrichments of a temple to Jupiter Tonans.

The creations of the modern Italian school, great and wonderful as they many of them are, still suffer from the errors of their parentage; and are, generally speaking, certainly wanting in those higher attributes to which we at first alluded, notwithstanding all the bright names which adorn the list of masters, and the many works which they have left behind them worthy of our respect and admiration. Yet, perhaps I ought to except in some degree the minor productions of some of the masters of this school—the loveliness exhibited in the beautiful gardens, where fount and bridge, temple and loggia, under the clear blue sky and amidst Italian foliage, speak visions of love and romance, and produce an imaginative world in harmony with itself.

In the Romanesque we find a certain rudeness of invention, yet fervour of thought and boldness of fancy, full of great merits. This style would appear the production of a society struggling

under many disadvantages, yet ruggedly bent on escaping from deteriorating influences, and on writing its name and destiny in characters of its own: not to be imitated or copied in detail—certainly not to be despised, but to be respected for its truthfulness, and earnestness, and honoured for its spirit. I need only mention the churches of Pavia, Verona, Lucca, Pisa, &c., to recal to your recollection the masterly and vigorous characteristics of this style; they all bear the impress of a certain freeness of idea, which is certainly poetry, though not of the first order.

To pass over these periods of art however thus lightly touched upon, let us look at the Mediæval styles—I mean all of those usually called Gothic: but as time and space confine us to a short limit, I wish to regard merely that of our own country.

In the Saxon examples, the art must have been at so low an ebb, that it would be fruitless to expect any of the higher expressions. In the Norman, we find an evident and increasing improvement, with, I think, much of the same feeling as the early Romanesque—instance Norwich Cathedral—which becomes greater and greater in the transition, till we arrive at the well-developed Early English; a change gradual, yet rapid, and every way marvellous. And here, I think, we may trace the evidences of a spirit and genius which, considering the state of society, the iron-bound darkness of the age, and the heavy curtain of ignorance that hung over the land, comes most surprisingly near in spirit and perfection to the Greek—an assertion which, to some, may appear bold and untenable; yet, let us consider carefully the beautiful proportions of some of the specimens of that style which still remain to us, the purity of invention, the graceful combinations, the pure style of ornament in the foliations, the play of light and shade in the deep undercut mouldings: the whole truthful, fine in conception, and most suitable to its purposes. And in calling all this to mind, let us suppose a cathedral as entire and complete; not with the admixture of other styles or periods, as we now see it, but of a piece from turret to crypt;—and will any one deny that such a building gives evidences of the highest poetic spirit, and must strike a beholder even as we have contended such a building should and must do? There are some, perhaps, who will say, "Very fine, truly, your gargoyles, grotesque, and sometimes indecent groups and figures, &c." To such I should reply, that these are but the greater proofs of my position: what are they more than the evidences of that state of society which renders the contrast of general perfection in the art so much the more to be wondered at; what more than the weeds here and there pressing through, but unable so to choke the soil as to interfere, except so slightly, with the plant which has grown up on its surface to beauty and grandeur, notwithstanding and in spite of all. Consider all this, and I think it may fairly be allowed that this phase of English art is not so far behind the lofty standard of the Greek. Let me be understood *not* to say that this period of English art is to be put side by side, and in the same parallel, with the Greek—but that it is much of the same spirit and order; and, in other words, that if the outward social influences had been the same, there is much to show that English architects could have achieved even what the Greek architects did;—and if so, then why not again now?

I cannot allow that it is by association that we admire this style so much as some people would have us think. It may certainly have some influence; but if it were wanting, I do not think we should admire the less. Association and habit may lead us to overlook and bear with what is faulty, but can never create beauties unless they actually exist. Nor do I see wholly the force of the notion that the Greek has the more intellectual expression, the other the more spiritual; least of all would I exalt the one at the expense of the other, and impart a false colouring by such empty jargon, thus applied, as Pagan and Christian. Every superior effort of genius is spiritual and intellectual—both, if directed rightly; and without doubt the class of mind and spirit was the same in both cases, although in the one sadly clogged and trammelled by outward influences. And I do think that this era of English art was infused strongly with what we have called its *poetry*; and it is a matter of great regret that it should have rested so short a time at this point. With surprise we see the rapid transition to the geometric period, which, had it been continued under those mental influences that governed the development of the Early English, would, I think, most likely have surpassed it—since the prevailing ideal was as pure, while the scope for design was more extended. Yet, alas! strange as it may seem, the cunning and wise spirit of the first inventors seems gradually to have left their successors, and to have become extinct; till in the Perpendicular it became less strong, and in the later periods of that style still less and less, till at last it became utterly debased and lost. This was sad: but it was a worse blow for high art when the revival styles were introduced; this shut off the connection with the past entirely, and what had been done previously became quite lost and forgotten; and although no man of genius can touch anything without making his mind and talent felt and acknowledged, yet not to call it *impossible*, he can hardly succeed in infusing the highest spirit into his works if he is forced to walk on the line chalked out for him, instead of choosing the path he would desire to travel. A Thorpe could do good things in a bad cause, yet in the revival styles generally, I confess I cannot discover (except with a few exceptions) that poetic spirit of which we have been speaking. Although a Wren erected a St. Paul's, which is one of the wonders of the world, we cannot but feel, I think, the falling off, and what it might have been otherwise the case; but while we do so, let us humbly do homage to the great genius which, under such circumstances, could do so well and magnificently, and deplore the arbitrary laws of fashion and public opinion that placed him in such a position: who was truly a poet and artist of the first order, and has left works which are indeed strongly imbued with that spirit and feeling which forms our subject. I have said that we have had architects among us whose treatment and governing tone of thought have been of the same order, and of as high an aspiration, as those of the Greek period; while certainly our architects of the revival school have shown themselves at least equal to any of those of the Palladian era; and nothing shall make me believe that in this day we have not men among us equal for brilliancy of thought and purity of taste to any that ever lived. The tone of society is higher, loftier influences are at work, than existed in the time of the ancient Greeks; and if things as great and beautiful do not come to pass, let the nation look for the cause in itself—in its arbitrary demands and own choosing—in its refusal to encourage those whose life is devoted to the study of the art—in its cruel fashion which has made a false state of things almost necessary—and as much in the mercenary spirit which governs all its actions: when the truth is, that high art can never be bought at too high a price, or its kindly influences valued too dearly.

It is probable that the present fashion of reverting to the mediæval styles for one branch of the art is not without its good effects; if we may only be led by it to search patiently for and find the lost thread which will guide us to excellence and improvement—that is, to seize the spirit and work it out—not be content with the form; and if we will only determine to scorn the quack prescriptions and abominable inculcations of a Cambridge Camden Society. We may expect to retrograde, indeed, if we are never to get beyond the school-boy work of merely copying what is put before us; nay, more, to ensure that nothing may be wrong, I believe, in some cases, one church has been transplanted by the exact copying of stone for stone, and moulding for moulding, to some distant situation, most likely very unsuitable for the design. What sad folly is this—what exquisite contempt does it heap on the architects of this generation.

A better and more inquiring spirit is, however, abroad; let us all hope that the system and faults we condemn will gradually be broken through and overcome. Above all, let us not despair; for as I remarked at the outset, the higher the aim, the more satisfactory must be the result of our efforts. Even though we fall far short of what we could wish, one thing is evident—that no man can be great when he studies only to be little.

MILITARY ARCHITECTURE OF GREAT BRITAIN.

On the Military Architecture of Great Britain. By the Rev. C. H. Hartshorne.—(Paper read at the Royal Institute of British Architects, May 6th, 1850.)

Mr. Hartshorne commenced by observing:—When I acceded to the request that I should offer you a few remarks upon the Military Architecture of the Edwardian Age, I did not sufficiently consider that my own researches had been of a desultory nature, and that they would necessarily want that practical illustration which the subject can only receive from those who make the science of architecture their constant study. Nor did I recollect that the branch of it to which I had turned the greater part of my attention, was one that had lain in comparative neglect by the profession, under an idea that it offers little deserving of imitation in modern buildings, and therefore that I should have to conciliate in some degree the comparative disfavour with which it has been generally regarded. Yet I have been encouraged, under the hope that having endeavoured to throw some fresh light upon a dark

portion of Architectural history, the facts I have brought together might add something to our limited knowledge of Pyrgology. Having carefully measured these different buildings, whose plans now hang on the walls (for without having applied the two-foot rule, and five-feet rods, I feel convinced that no remarks would be entitled to the least consideration,) having examined them in analogy with the respective systems of fortification peculiar to the period, and in detailed connection with each other, and subsequently consulted those evidences stored up among the national records which serve to disclose the circumstances and the cost of their erection, I thought, as we have all a common object in view, I might venture to lay before you the conclusions to which they have given rise. But I undertake this agreeable office, not influenced by the supposition of instructing so many from whom I ought to learn, but rather with the view of simply stating the results which this combined method of illustration has originated in my own mind. The announcement has, perhaps, been made public in too extended and general terms, for a discussion of the Military Architecture of Great Britain would occupy more time than the Institute might feel justified, even under more competent guidance, in bestowing upon it; and I will therefore, for present convenience, confine the attention to those leading features which the subject presents under the Norman and Edwardian periods. Passing over the numerous earthworks thrown up by the Britons against the Roman invaders, fortifications which, especially on the North Welsh borders, excite our astonishment for their magnitude and strength; and, disregarding those carefully built walls, which the conquerors subsequently erected to preserve their newly-acquired possessions, I will come at once to a time when there is direct evidence to show the precise date, the methods adopted, and the charge of building, some of the most important English and Welsh Castles. Of the Conqueror's castles, we know little more than what we read in 'Domesday,' which is simply that of the forty-nine enumerated in his survey, he built eight himself, and the rest were erected by his barons. Our only true source of information concerning them are the official documents of the time; and, after the great survey, we have a break in the series of records till we come to the Sheriffs' accounts.

Mr. Hartshorne then proceeded to explain the nature and importance of the official documents still existing, and known as the Pipe Rolls, the Clause Rolls, the Liberati, the Patent, and the Minister or Chamberlain's Accounts, all of which are kept in regnal years. The following may serve to illustrate the value of the information to be obtained from examination of these documents. From the Pipe Rolls we learn the dates, as well as the cost of construction, of different portions of the castles described in them:—

				£	s.	d.
	Bridgenorth. The Tower.					
Temp. 15, 17 Hen. II.		A.D. 1167—1172	cost	36	4	1
.. 28 Hen. II.	Repaired	1182	..	2	16	8
.. 8 Rich. I.	Repaired at base	1196	..	8	5	0
.. 8 John	Repaired	1206	..	10	0	0
	Dover. Turris.					
.. 30, 31, 32, 33 Hen. II.		1184—1187	..	797	10	3
	The Cingulum built 1186. Mauricius Ingeniator.					
	Colchester.					
.. 26 Hen. II	Turris repaired	1180	..	10	8	8
.. 6 John	Repaired					
	Forcinus Ingeniator.					
	Berkhampstead.					
.. 6 Hen. II.	Works on castle (& ingeniator 48s.)	1160	..	43	6	8
	Kington.					
.. 33 Hen. II.	Repairs of palisades	1187	..	0	5	0
	Cambridge.					
.. 19 Hen. II.	Works on castle	1173	..	31	0	0
	Bedford.					
.. 29 Hen. II.	Castle repaired	1183	..	12	0	0
	Scarboro'.					
.. 7 to 15 Hen. II.	Castle and keep	1161—1169	..			
	Orford.					
.. 12 Hen. II.	Commenced	1166	..	333	0	0
.. 19 Hen. II.	Fosse	1173	.. total	438	1	9
.. 34 Hen. II.	Tower repaired		..	10	12	0
	Hastings.					
.. 18 Hen. II.	Drawing stone for the turris	1172	..			
	Arundel.					
.. 33 Hen. II.	Flooring the turris, and for making a herbary before the King's chamber	1187	..	12	13	4
	Bogis.					
Temp. 18 & 19 Hen. II.		A.D. 1172—1173	cost	324	0	0
.. 34 Hen. II.	Finished		.. total	297	16	6
	Nottingham.					
.. 17 Hen. II.		1171	..	274	14	9
.. 31 Hen. II.	Baly completed.					

Mr. Hartshorne then explained, referring at the same time to the plans and drawings on the walls, the parts and appendages of a castle, their uses, and relative positions, viz.:—The Keep—the Fosse—the Barbican—the Portcullis—Stockade—Enceinte, or Cingulum—the Baly—Donjon—Loops—Oillets—Cross Oillets—Battlements—Crenelles—Embrasures—Merlons—Alures—Vawmer—Postern Gate; or Sally Port—Drawbridge; or Pons tornatilis—Gemews—Bastions—Towers—Turrets—Machicolations—False Machicolations. He next alluded, in further explanation of the subject, to the instructive and magnificent pile of Caerphilly, with its leaning tower, 9 feet out of perpendicular, and to Bridgnorth Castle, whose ruined tower inclines some 25 feet, and bears evident marks of reparations at its base having been made at different periods.

The names and duties of the officers attached to a castle were then described—viz., the Constable; the Ingeniator; the Attiliator; the Garritor, or Sentry; the Porter; and the Watchman, for whose shelter shutters were contrived in the embrasures of his watch turret. As Engineers, mention was made of Alnod, at the Tower, temp. 20 Hen. II., 1174; Yoo, at Windsor; Bayard, Nottingham, 7 John; Ganfridus, at the Tower, 37 Hen. I.; Albert and Urric, Hen III.; Richard, Edw. I.

A succinct description of Norman castles followed, in which it was stated, that they were generally built after the same model, and that they have usually a keep, or square building, on a mound or elevated portion of ground. A remarkable feature of the keep is, that the *entrance is on the first floor*. The walls are strengthened at the sides by shallow buttresses, which die into the face of the work before they reach the summit. The earliest have no portcullis. They were *defended by outer walls*, of the circle of which they sometimes form a part, as Pevensey.

The keeps are of various shapes, the quadrangular form being the most common; as at Rochester, Porchester, Canterbury, Rising, Heddingham, Norwich, Newcastle. Sometimes they are of polygonal shape, as at Kilpeck, Caerdiff, Coningsboro' Chillham, and Orford. At others, they are circular, as at Skenfrith, Pickering, and Launceston, to which class may be assigned Alnwick. The solid type of the Norman keep passed, by an easy gradation, into the geometrical form, as seen in Clifford's Tower at York, and later again at Barnswell, 1264, Hen. III. The transition from this to the concentricity of the Edwardian, was natural and easy. Of the Norman and Edwardian forms, all later ones are only modifications.

To illustrate the gradual progress which took place in building these castles, attention was called to the Castle of Alnwick, in Northumberland, which was commenced by Yoo de Vesci, temp. Hen. I. William de Vesci, 26 Edw. I., having no legal issue, enfeoffed it to that great prelate, Anthony Bek, Bishop of Durham, in social confidence that he should hold them for William de Vesci, his illegitimate son, till he came of age. But being irritated by some slanderous words he had spoken, he afterwards sold the castle, 19th Nov. 1309 (3 Edw. II.) to Henry de Percy. He made large bequests to Fountains' Abbey, where he was buried before the high altar, dying in the 8 Edw. II. His son Henry, who succeeded him, built the octagonal towers of entrance into the inner baly, about the year 1350, as is shown by the armorial bearings of the Nevilles, Fitzwalters, and Umfruanville, inscribed on shields under the battlements. This castle was visited by King John, Edw. I., Edw. II., and William, king of Scotland, was taken prisoner under the walls in 1174.

The remaining portion of the paper had reference to the Edwardian Castles of Wales, and consisted chiefly of a detailed account of the progress of the works at Conway and Caernarvon, being the result of a very long and diligent research, among the records before alluded to, in connection with a careful examination, measurement, and delineation of those buildings. Mr. Hartshorne demonstrated that the works were commenced at Caernarvon, 10th November 12 Edw. I. (1284), six weeks after the execution of Prince David, at Shrewsbury; and at Conway, 28th October, 11 Edw. I. (1283), thus showing that the latter castle preceded the former by a few months in the date of its erection; and that the walls round the town of Caernarvon were built in the 14th year (1286), when some portion of the castle was covered in with lead, and the works were in progress in the fosse. That in the same

year the castle at Harlech was begun, and that at Criccaeth repaired. That the works at Caernarvon were in progress, 19 Edw. I. (1291) That little had been done besides the town walls and the fosse round the future castle, when Edw. I. visited the town, for the first time, 1st April, 1284. That his son, the Prince of Wales, was born there on the 25th of the same month, but by no possibility in the Eagle Tower, as usually asserted. That after little progress in the 19th and 21st years, what had been erected was rendered useless by Madoc's insurrection, in the 23rd year (1295), and the works were begun anew from the north-east angle, and thence along the southern side. That the records and the change in the masonry showed the north side to be of different ages—the earliest some time between 23 and 29 Edw. I. That the Eagle Tower was the work of Edw. II., as shown by records expressly relating to its erection, and by the form and character of its mouldings. That it was roofed in the month of November, 1316; floored in February, 1317; and the eagle was placed on the battlement the first week of March. That the upper portion of the north side of the castle, entrance-gate, &c., were finished 13 Edw. II (1320), and the royal effigy fixed there the last week of April, in the same year.

This detailed statement of the progress of the works entirely controverted the general opinion, that Caernarvon Castle was constructed in the short space of twelve months, and proved that the present buildings were the labour of 38 years, and being carried on from 1284 to 1322, even extended into two reigns. The early progress of Conway was traced in a similar manner, and an account was also given of the actual state of the thirteen royal castles in North and South Wales, 17 Edw. III. (1343), which had been granted by him to his son, the Black Prince, when a large sum was estimated to be required for repairs, nearly half of which was essential for the castles of North Wales.

Many of the extracts from the calendars, expense rolls, and other documents, quoted in the course of the paper, were highly interesting, from the precise way in which they exhibited the industrial economy of the time, the rate of wages, the price of material, and the method of carrying on large works; and the paper itself was illustrated by several plans and drawings of a large size.

Mr. Hartshorne having concluded his paper, Mr. Cockerell, the Chairman, said—"All present will, I am sure, join gladly in returning thanks to the Rev. Mr. Hartshorne, for the very luminous discourse he has given us on the Castles of Great Britain, and more especially on those of the time of the two first Edwards. To a great country, rich in historical associations, such a subject must, at all times, be deeply interesting, and it is one well worthy the consideration of the antiquary and the historian, as illustrating a portion of our national architecture. It is, moreover, especially interesting to us, as revealing the relative state of the art of building, and of our own profession in those early times, as well as the rate of wages, and the condition of the working community. We are greatly indebted to our reverend friend for investigating the very minute and authentic resources which he has opened to us; and in expressing our obligations to him, permit me to say, that I do not know which to admire most, the elegance, or the perspicuity with which he has presented to us this curious lore, which tends in so remarkable a degree to illustrate the state and position of our art in the middle ages."

Mr. Donaldson: "The Institute is much indebted to our reverend friend, for making its members acquainted with these remarkable documents, relating to the construction of this interesting group of castles. That no body of men could, I believe, appreciate better than this body, the importance of the information he has placed before us, will, I think be acknowledged when I state, that about ten years ago, the Institute offered its medal for the best restoration of an ancient castle, and that we possess a very skilful set of plans representing the castle of Sheriff Hutton, designed by Mr. Sharp, jun., then of York, and accompanied by a learned dissertation upon the relation the different parts of the castle bear to each other. The reverend gentleman, admirable as was his paper, has stopped short on the threshold. He has given us the dates and cost, and its progressive development; but it would be still more interesting, if possible, were he to give us an account of the connection of the different parts of the castle, with the reference they bear to each other, and the reasons for the differences which exist between them—why one tower should project more than another—why some should be polygonal, some round, and some of complex configurations—why, in short, there should be such differences under similar circumstances as those apparent in the examples now displayed on our wall. It would be interesting to know how far the builders of these castles were acquainted with that well known rule of fortification, by which the inner gate was so placed that, as the attacking warriors approached, the sides of their column were inevitably exposed to the assault of the defenders. It would also be interesting to understand the reasons for the different modes of defence adopted in various castles—the difference in their internal arrangements—whether any rule guided the mode of placing the apartments of the family of the lord of the castle, his domestic servants, his military retainers, and the stores, commissariat or warlike. It would, moreover, be desirable to know, what was the proper position of the keep; whether it ought to be part of the defence of the enceinte, or in the centre of the court, and whether, at different periods, and in different parts of the country it assumed diverse positions. Again, it would be interesting to know if there was any particular locality for the great hall, or chapel, in the castle; which was generally placed in the inner parts, and which nearer the enceinte; whether the enceinte itself was always a large continuous wall like that of Alnwick; and, what in short, was the purpose of every portion intended to serve in these great military defences. Many of us now present, who have visited Greece, cannot, I think, help drawing a comparison between the castles now exhibited to us and the Acropolis of Athens, and the other ancient cities of that country; and in so doing, we find several points which appear to me to be analogous, as the high walls forming the enceinte, and the central building inclosed within it—in the one instance, the great temple—in the other, the Norman keep. It is interesting to find these features of the ancient Grecian Acropolis repeated in our own mediæval fortresses. It will be observed that many, if not most of the castles here illustrated have an outer and inner ballium or court, here termed baly. It has occurred to me, that possibly the Old Bailey of London may derive its name from having been a ballium or court attached to New Gate, which anciently stood at the end of Newgate-street. I leave it to City antiquaries to enquire into this presumed coincidence. I hope the reverend gentleman, who is deeply versed in this subject, will consent another time to instruct us further by taking a larger sphere, and making us better acquainted with the military spirit of those early times. I should like to have some comparision of the cost of erecting these Edwardian castles and those of modern times, such as Penrhyn castle, or the alterations at Windsor castle. Indeed it might not be uninstructive to compare the outlay on our modern Houses of Parliament with that on the buildings so ably brought before us to night." Mr. Donaldson concluded by moving a vote of thanks to Mr. Hartshorne.

Mr. Tite, in seconding the vote of thanks, said—"I also must express a hope that our reverend friend will hereafter carry his historical inquiry a little further, and explain what has often struck me as very singular—viz., the poverty of the Scottish castles, as compared with the grandeur and magnificence of those of Wales. All the Scottish castles together, could, I believe, be put within the enceinte of Caernarvon Castle; while Bute Castle might be ensconced in the Eagle Tower. I do not know whether the reverend gentleman has confined his researches in the Pipe Rolls exclusively to these castles, or whether, indeed, those ancient records contain any account of the building of the Scottish castles. I would also ask a question with regard to the keeps. There is no keep proper at either Caernarvon or Conway; at least no such keep as the tower at Norwich Castle, and in other Norman castles, to which the defender of the building could retreat as a stronghold when the enceinte was taken. How is that omission to be accounted for? There was, no doubt, a similarity in the character of the erections for defence in Greece, as for instance at Mycenæ and at Athens, and that of the buildings now before us. There was the bold escarpment, or wall built upon the summit of a natural escarpment, as in these Norman castles; and in all, great skill was shown in the way in which the natural irregularity of the ground was turned to advantage. It would be interesting to know the mode of construction employed in the erection of some of these great towers, as well as the thickness of the walls compared with the area they inclose; whether the walls are of solid stone, or merely ashlar filled in with concrete, and bonded; and in short, their general mode of construction, as in all such enormous superstructures great care is requisite to prevent settlements and other evil consequences. I must say, it struck me that 8d. a-day to the clerk of the works was a large amount of pay, as compared with that of the workmen, and particularly, when we consider that 30 or 40 years were expended in the erection of these buildings, instead of 30 or 40 months, as in the present times. I think we are much indebted to our reverend friend for the great industry and talent he has displayed in his able paper."

Mr. Foggo said that one account stated the master of the works received 13*s.* per week, which at the present value of money would be 10 guineas a week. The whole cost of Caernarvon Castle was stated to have been 250,000*l.*, but that did not include various expenses, such as carrying the stone from the quarry, which were imposed upon the inhabitants of the neighbourhood.

Mr. Fowler having suggested that the vote of thanks should include the name of Mr. Salvin, to whom they were indebted for the drawings by which the paper was illustrated,

The Chairman replied that he had a resolution in his hand to that effect, and expressed a hope that Mr. Salvin would give them a few remarks upon his illustrations some other evening.

The vote of thanks was then passed by acclamation.

CEMENTS AND STUCCO.

On the Propriety of the Application of Cements or other Artificially-formed Materials to the Exteriors of Buildings. By James Thomas Knowles.—(Paper read at the Royal Institute of British Architects, May 27, 1850.)

In submitting the paper which I have now to read, I am influenced by the appeal of the Council to the Members of our Institute for active co-operation; by a desire to assist in removing some of those objections which have been often made to a very valuable class of materials; and by the hope of eliciting a discussion which may be to some who are assembled here to-night both interesting and instructive. But, before I enter upon this difficult and much-vexed question, I wish to state distinctly, that wherever I may express an opinion of my own, unsupported by actual observation, I shall do so with great diffidence, and with the feeling that such opinion may be proved, hereafter, to be erroneous; because I feel that, before the nature of cements or stuccoes can be clearly understood, a larger amount of statistical details, and a much more correct knowledge of the chemical changes which are produced by apparently minute differences in the materials themselves or in the conditions under which they are applied, than is possessed at present, are absolutely necessary.

As my object, on this occasion, is rather to state the result of my own observation and experience, than to repeat what may be gleaned from the works of those who have written upon the subject, I would also ask you to excuse what may appear like egotism in the allusions which I shall have to make to buildings of my own, and to believe that I adopt this course simply because it is impossible for me to speak, with the same degree of certainty, of works with which I am less intimately acquainted.

Although the practice of covering the exteriors of buildings with some description of plastic materials appears to have prevailed from a very early period, it will, I think, be readily admitted, that in our own age and country this practice has been carried beyond all former precedents. It would be quite impossible, on an occasion like the present, to enumerate all the causes which have produced, or have assisted in producing, this result; but, perhaps, as among the most prominent of these, I may mention the cold and humid atmosphere of our northern climate; the impossibility (in many localities) of obtaining, except at a cost too great to be incurred, such materials as will effectually resist the destroying influences of rain and frost; and a growing inclination on the part of our employers to add something of the beautiful in form to that convenience of arrangement and fitness for the intended purpose, without which the most elaborate productions of our art are really failures, or can at best be deemed but splendid errors.

It is true, that, when the practice of employing stuccoes and cements for covering the exteriors of buildings was first adopted, the science of geology had not revealed that valuable page in the great book of nature which has recently attracted so large a measure of study and attention, and that the nature and quality of the materials which compose the crust of our planet are, through the aid of that modern science, better understood by us than they could be by those who were engaged in the art of building before this source of knowledge had been revealed. Yet this additional knowledge upon a subject so deeply interesting to the architect, has tended to confirm the impression which previously existed, by showing him, that in many portions of the united kingdom no building stone can be obtained capable of effectually excluding moisture, or of resisting for any lengthened period the vicissitudes of our climate; and by convincing him, that, in order to secure in such cases, dry, healthful, warm, and comfortable habitations (especially when buildings are rapidly erected, and occupied immediately after their completion), two things are absolutely necessary, and a third is exceedingly desirable:—

1st. That the outer face of all the external walls should have a covering, or skin, of some material impervious to water.—2ndly. That the moisture from the earth should be prevented from rising into the brick, or stonework, by the introduction of some waterproof material into all the external and internal walls and partitions immediately above the ground level.—3rdly. (Where bricks are employed, and a proper amount of careful supervision can be exercised)—that the external walls should be hollow, with an air space of 4, or 4½ inches between the external and internal work, excepting at the jambs of the openings, and the points of junction with the internal walls.

That the necessity for these, or similar precautions, in the erection of dwelling houses in exposed situations, is perfectly well known to the elder members of the profession, and that they adopt them in their practice, I entertain no doubt; but as their advantages may not be equally clear to those who have yet to enter upon the practical department of our art, and lest they should imagine that I am speaking theoretically, and not from actual experience, I will mention—That the house, of which one of the elevations is now exhibited, was erected about six years ago, in an exposed situation, and on a stiff clay soil; that the carcass was carried up in an unusually wet autumn, and the walls exposed to heavy and continuous rains; that no wall battening was used in any portion of the building, which was roofed-in at the end of December, and completed and inhabited by the end of the following October, at which period it was quite fit for occupation; that there has never been since that time the slightest appearance of damp in any portion of it, from the basement to the roof, nor is the smallest settlement perceivable; and this result is, I believe, mainly, if not entirely, attributable to the adoption of those precautions which I have mentioned as being, in my opinion, essential in nearly all cases, and to one other, which is only important on clay soils—that is, the covering of the whole area occupied by the building with a bed of concrete, which should not be less than six, and need not be more than twelve, inches in thickness.

To those who have been accustomed to build only in London, or in other towns and cities, it would, I believe, be quite impossible to convey an adequate idea of the difficulties which must frequently be encountered by those to whom the erection of isolated houses in very exposed situations is intrusted; when (as very frequently happens) no such stone or bricks can be obtained as will effectually resist the rain, and prevent it, when accompanied by heavy gales of wind, from passing through the walls.

I could, if time permitted, mention many remarkable instances of the mechanical force with which the rain is sometimes driven horizontally against the walls of buildings in elevated positions; but I will select one only, which made a great impression on my mind. During a visit to a large building in course of erection on Black Down (the highest ground, I believe, in North Devon), I observed a portion of a nine-inch partition wall saturated with water. As the building had been roofed-in some weeks before, I was a good deal surprised at this appearance; but I had an opportunity a few days afterwards of witnessing what explained to me the cause of it; for, being on the spot during a heavy gale of wind and rain, I stood for some time watching the result, and saw the rain passing through a window opening across eighteen feet of space, and striking with great force against the opposite internal wall, and in the course of about an hour making its appearance on the other side.

Very shortly after witnessing this occurrence, I was called upon to examine a church, which had been erected in a similarly exposed position, through the walls of which (even those of the tower), the rain found admission to the interior in very large quantities. Three or four years having been suffered to elapse, during which this evil was found to be continually increasing, the walls were covered with stucco, of the kind which I shall have hereafter to describe, which proved in that, as it has done in all other cases with which I am acquainted, perfectly effective.

Contenting myself with the remark, that in no single instance have I known the external application of a well-made and carefully-used stucco, to fail in accomplishing the desired object, I will proceed to combat those which appear to me to be the strongest of the objections which are advanced against this mode of protecting and adorning the exteriors of our buildings, viz.—

That cements and stuccoes are not durable, and require frequent and expensive reparations.

That they are very costly; not so much at first, as by reason of the colouring or painting in oil which, it is thought (erroneously I believe), that they afterwards require.

That they are false and deceptive, inasmuch as they, being artificially-formed materials, do, in some measure, assume the appearance of natural productions.

That their introduction has led to all that is false in design, and defective in construction.

And that, when employed in decoration, the enrichments are deficient in that sharpness of outline, and delicacy of finish, by which the productions of the chisel are distinguished.

Now, I must readily admit, that a very large proportion of the cement and stucco work, which we see in London and its neighbourhood, is so faulty in design and defective in execution that it is difficult to find language strong enough for its condemnation. I know that many of the structures which we see bedizened with what are intended for, and by some, perhaps, are dignified with the name of, decorations, are indeed but whited sepulchres. That many of the bricks used in them might, by a strong man's hand, be crushed to powder. That the mortar is composed of earth, dug from the foundations, mixed with a very small quantity of white chalk lime. That the timbers are defective, both in quality and scantling; and that, in short, the whole affair, from the foundation to the roof, comprises all that is miserable in construction and false in taste.

But I cannot think that these defects are referable to the use of stuccoes and cements, or that by the external application of these materials, structural defects can be successfully concealed. On the contrary, I believe that the cracks and openings produced by the settlement of piers or arches; by the shrinkage of timber, improperly introduced; by the fracture of stone lintels, or other such like causes, are to the full as conspicuous in a stuccoed building as in one which is faced with brick or stone, and quite as difficult to repair effectively. Indeed, I feel so strongly the necessity of extreme care being taken in the construction of buildings which are intended to be covered with cement, that I not only turn inverts under all the openings, but frequently omit also the reveal arches and the timber lintels; carrying, instead of them, relieving arches through the whole thickness of the wall. I have never yet seen any cracks or settlements in the walls of buildings thus constructed, when carefully stuccoed; and I see no reason why this mode of building should not be almost universally adopted, when cement or stucco are intended to be used, as it is more effective and durable, and is not at all more costly.

It has been frequently asserted that no chemical or mechanical combinations of matter will result in a successful imitation of what has been effected in Nature's laboratory; and that no artificial materials can be made equal in durability to natural productions. Yet it would, I think, be difficult to find in England, any description of building stone more capable of withstanding for a lengthened period the vicissitudes of our climate, than thoroughly well made, and well burnt bricks, and *terracotta*.

It is true, that the firing to which bricks and *terracotta* are subjected may be fairly considered as constituting a great difference in their power of resisting atmospheric influence, as compared with any of the cements which are now usually employed; but it is quite certain that cements and mortars have been made, which, for hardness and durability, were almost, if not quite, equal to the hardest bricks. And I cannot doubt the possibility of again doing in our own time what was certainly accomplished at a period when, however much grandeur of conception and just appreciation of beautiful forms might have exceeded those with which mens' minds appear to be endowed at present, the physical sciences were but little known, and contributed only in a very slight degree to the comforts and the social enjoyments of the human race. A proof that I am not overstating the power of resistance to atmospheric influences which mortars and cements, when properly prepared, do undoubtedly possess, is afforded by a piece of Roman mortar from Wroxeter now exhibited, which has evidently been used as an external cement or stucco, and which must have been exposed to the action of rain and frost for fourteen or fifteen hundred years.

It is said that failures frequently occur in works which have been executed in cement, and that the decorations produced in artificial materials are always deficient in that sharpness of outline and delicacy of feeling which constitute the great charm of architectural enrichments. But I would ask, whether it is not possible to lessen, if not wholly to remove, these very grave objections, by great attention on the part of the architect in designing, and especially in inspecting the modelling of his enrichments whilst in the clay? By a determination, on his part, to become thoroughly acquainted with the nature and properties of all such cements as he intends to employ for the covering or decoration of his buildings, whether internally or externally; so that he may be enabled to form a correct opinion when he sees the work in progress, whether the materials have been properly prepared by the manufacturer, and then sent to the building in a state fit for use by the contractor, and are being judiciously mixed and applied by the workmen and labourers. By employing in the execution of his works such men only as are thoroughly masters of their business, making them responsible for the reparations and reinstatements of any portions of the works which may fail within five or seven years after their completion; and by securing the services of clerks of the works, or foremen, who are well acquainted with the nature of the cement to be employed, and who will keep a vigilant eye over the proceedings of the workmen.

But some of my friends will, doubtless, tell me, that if, in order to prevent failures in the effect or in the durability of cement work, all this care and circumspection are required, failures and imperfections are quite certain to occur. This may be true; but if true as regards cement, it is also true of other works required in the erection and completion of a building. And how, let me ask, can the imperfections so often found to exist in the plumber's work, and in the drainage of our buildings; in the carpentry of the roofs, floors, and partitions; in the foundations, and the brickwork, be prevented? How can the disintegration and crumbling away of the most prominent members of stone cornices, strings, balconies, and chimney tops, within a few years after their completion, be avoided, excepting by the same degree of knowledge, care, and skill on the part of the architect, the contractor, the clerk of the works, the foreman, and the workmen, which I have insisted on as essential to the successful employment of cements?

There are, however, among those who have most strenuously opposed the use of these materials, a considerable number who ground their objections not on the want of durability, the chances of failure, or the extra cost; but on their want of reality, their resemblance to some natural productions, and the smallness of their cost, as compared with the stone casings which they sometimes resemble. Now, however desirable and proper, and commendable it may be, and doubtless is, to introduce into the structures which are reared in honour and for the worship of the Great Creator, the most valuable and the choicest of earth's productions; yet it must, I think, be admitted, that the qualities of the material in which the thought of a great artist is embodied (so that it possess but durability and beauty), are in all other cases of very secondary importance. I fear, however, that the disposition to place so high a value on costly stones, and woods, and metals, which appears lately to have prevailed amongst those who profess to be the patrons of the arts, is calculated to produce on the minds of the people generally, false impressions; because it leads them to admire that which is difficult of attainment except to the possessors of great wealth, instead of that which is truly grand and beautiful, and original in design.

That species of admiration which is excited by the costliness of the materials employed in works of art, has always appeared to me to partake considerably of the vulgar and the barbarous. For, as much as the heavens are higher than the earth, so much, do I believe, the emanations of the mind to be above and beyond the mere vehicle in which they are embodied. Whatever is really beautiful in form, or truly harmonious in colour, should be enshrined, as amongst the most precious of man's productions; and I cannot doubt that the time will come (although, perhaps, not in our day), when the immaterial thought of the artist shall be more highly valued than any stones or woods, or metals, however rare or costly, in which it may be clothed. Much better is it, in my opinion, to have the emanations of deep thought, the creations of those minds which have been embued with a due appreciation of the beautiful in form, embodied in materials which might endure for only half-a-century, than the eternal stereotypes we now see rising throughout this great and wealthy country, perpetuated in stone which would endure for countless ages.

It is not, I believe, because there exists among our countrymen any lack of mind to conceive, or of constructive skill to carry out the most gigantic undertakings, that so comparatively small a number of buildings remarkable for beauty, for originality, or for grandeur of design, have lately been produced. But, partly, because mens' minds have been directed more towards other objects than the arts; partly, because the carelessness of the public, and the unaccountable apathy of the profession, have allowed a small and non-professional party to assume the direction of our art, and

to introduce a movement of retrogression to the styles and fashions of a former age; which must, I fear, if not soon checked, prevent for some long period all progress and improvement. And is it strange and unaccountable, that architects and architecture are favoured with so small a share of public consideration in the present day, when it is remembered that, whilst in almost everything connected with our social condition there has been manifested the strongest determination to encourage progress and improvement—those who profess to be the patrons and supporters of this really great and noble art, have exhibited an equally strong determination to go backwards; to prevent, so far as in them lies, the introduction into the ecclesiastical edifices of the nineteenth century, a single form or feature which has not been copied from some mediæval building; and even to disfigure the windows of our churches with such representations of the human form as were produced by the old glass painters, because they were unable to give more correct delineations?

Professor Cockerell, in (I believe) his fifth Lecture of last Session, at the Royal Academy, speaking of the fashions which have prevailed in architecture, is reported to have said:—"The proofs of this fact (fashion in architecture) abound. Churches were Grecian, and for the last twenty years have been Gothic; intensely Roman Catholic. The sense has been wanting to understand that we do not want a Greek temple for the reception of a chryselephantine statue, nor a Roman church for processions, and a sight only of the Eucharist; but a Protestant auditorium, suited to the Anglican ritual, to which great purpose, all form of dress, of whatever order and fashion, must bend and adapt itself." In the opinions thus expressed by the learned professor, I believe that many thousands of his countrymen do most cordially agree.

Without the slightest intention of making any disparaging remarks on the labours of those architects who have, with so much care and skill, sought out and given correct and beautiful illustrations of the structures and architectural details of the middle ages, I would respectfully suggest that the time has now arrived, when the efforts so strenuously made in obtaining intelligence on these subjects may well be slackened, and the talents of those gifted individuals be directed to investigations which may result in the production of novelty, beauty, fitness in design, and of greater economy, combined with durability and beauty in the construction of our buildings; in adapting to the wants of the existing generation those great discoveries in physical science which may, and ought to increase so largely the diffusion of comfort and rational enjoyment amongst all classes of the community; and in making our age and country as remarkable for the dissemination of a love of true art amongst the masses of the people, as it is for an amount of commercial energy and enterprise which stand unrivalled in the annals of the world.

The homes of England have now, for many years, been considered as worthy of our best attention, and no small portion of that industrious perseverance for which our countrymen are justly celebrated may be attributed to the desire of possessing a commodious and healthful dwelling which so extensively prevails amongst them. There was a time when men cared little whether or not these homes were situated in the country, so that they contained the requisite accommodation for their families. But this indifference to position, which some time before the introduction of railway travelling had been gradually lessening, has, since the development of that wondrous system, almost wholly disappeared; and men of all classes and conditions, influenced mainly by the facilities for travelling which are now placed within their reach, appear determined to find, or to build, in some rural district, such habitations for themselves and their families as shall combine, with every provision for comfort and convenience, as much of symmetry and beauty as the talent of their architect and the means at their disposal will allow. Whilst, however, men of various ranks and stations are eagerly bent upon obtaining the unquestionable advantages of a country residence, and are disposed, in many cases, to incur for the attainment of this object, such an expenditure (however large) as may be really necessary, they are almost invariably unwilling to make any considerable addition to their outlay, either for the purpose of building or casing their houses with stone, instead of artificially formed materials, or for the introduction of features which, although generally found in ancient buildings, are now, from changes of habits and modes of living, no longer useful. That this feeling, whether wright or wrong, does very extensively prevail, not only among the professional and trading portions of the community, but that it is also found in many cases to exist among those who are possessed of high rank and station, must be well known to many members of this Institute.

Now, if we admit that a dry, commodious, and well-arranged house does very materially assist in promoting the health and happiness of those who occupy it; that the present cheap and easy mode of travelling is leading to a very large increase of private dwellings in the country; that those by whom these dwellings are erected, although for the most part anxious to combine convenience with beauty, will not consent to any considerable increase of expenditure in the employment of natural instead of artificial materials, when the latter are well adapted for the required purpose, and possess both durability and beauty; and that in many localities no stone or bricks can be obtained, which of themselves are capable of excluding rain, or of resisting the destroying influences of frost; it must, I think, be also granted, that few subjects can be more deserving of our best attention, than those artificial coverings or skins which are, in many cases, really indispensable, and might in many others be most advantageously employed.

To those objections which are made against these artificial coverings on account of the expenses said to be incurred in reparations, and in frequent repetitions of colouring or painting, I attach but very little weight, because my own experience has convinced me, that if the right materials are employed, no painting or colouring will be required, and that the total cost of reparation (when the materials are of good quality and the work well executed) does not amount to any thing like one per cent. on the original cost, within five years from its first completion; and after that period has elapsed, I believe that its durability for fifty, seventy, or even a hundred years, may very safely be predicted. That the extent of durability and adaptability which artificially formed materials possess, or which by further improvements and discoveries may hereafter be obtained, is the really important question, it seems to me impossible to doubt; for it surely never can be seriously asserted, that if by an expenditure of one thousand pounds, or the amount of labour which that sum represents, we can obtain in an artificial material more warmth and greater freedom from damp internally, with as much beauty and durability externally, as can be produced for four thousand pounds in stone, we are to adopt the latter, and reject the former? Shall we not then act like faithful stewards if, in many cases, when called upon to prepare designs for the dwellings of our countrymen—buildings which are to be numbered among the homes of England—we devote the money which might be expended in an external case of stone, to the increase of internal accommodation; to the enlargement and proper decoration of the apartments in which our clients and their families are to spend by far the larger portion of their time; to rendering the building proof against the ravages of fire; to providing copious supplies of water, and numerous accommodations and conveniences, which although required by the habits of the age, and essential to the comfort and well-being of the tenants, are yet not always found even in the most costly of our houses?

As to the peculiar properties, the excellencies, or the defects of the various cements and artificially formed materials, to which the attention of the profession is so frequently solicited, it is not my intention, on this occasion, to say much. There is, however, one material which can perhaps scarcely be called a cement, according to the general acceptation of the term, to which my attention has been a good deal directed, and which has been very extensively used under my directions. It is one with which most of you are familiar, and I should not venture to offer the few remarks upon it with which I am about to trouble you, if I did not believe that I have had more than ordinary opportunities of testing its capabilities in various ways, and in remarkably exposed situations. As it is one, moreover, with which manufacturers of cements have little or nothing to do (the process required in its preparation being extremely simple and inexpensive), whatever I may say in favour of its durability and beauty will not tend much to the advancement of any particular interest.

This material, usually known as stucco, is in reality nothing more than mortar, formed either of blue lias lime, ground or slaked, and mixed with pounded slag from the smelting furnaces; or of the grey stone lime so extensively used in London, ground and mixed with clean, sharp, carefully-washed, silicious sand, in the proportion of one part of lime to three parts of sand, excepting for the outer surface or facing, where nearly equal parts of lime and sand are generally used. The lime and sand (whether silicious or metallic) should be mixed well together (or gauged, as the workmen call it) in small quantities, and applied immediately to the work, which, in order to ensure success, should, in all cases, be first well saturated with water. With this mortar, formed in either of the two ways which I have mentioned, and used by experienced and skilful workmen, not only may a durable casing impervious to

water be obtained, but mouldings and enrichments of all kinds can be also executed, with a sharpness and delicacy of finish which it is impossible to surpass.

In the building here represented, which was erected about seventeen years ago, and which occupies a very elevated and exposed site on the borders of Hampshire, not far distant from the sea—the capitals and bases, and the flutings of the shafts of the columns (which were executed in a most masterly manner, and with a degree of accuracy and truth, as to entasis and details, which left nothing to be desired) remain as yet uninjured. And the arrises of the fillets between the flutes, even of those columns which are exposed to the south-west, without protection of any kind from the violence of the winds and rain (with which, from that quarter, we are so often visited) were, when I saw them about ten months since, as sharp and perfect as any which can be formed by the chisel of the mason.

I could mention a great number of buildings, some of them much larger and more highly decorated, on which the same material has been successfully used. But I have selected this, because it was the first of any magnitude on which I ventured to employ it; and it is the oldest work of my own to which I can refer. It is true, that a period of seventeen years (although much longer than some of the building stones which have been used in this country would endure under the same influences) offers but a narrow foundation whereon to build an hypothesis as to the permanent durability of any kind of material. But we all know that mortar, such as that which I have mentioned, will (if it escapes the trials to which it is subjected for the first few years, before the induration produced by the absorption of carbonic acid has made much progress) continue to increase in hardness, for a period of which the limits have never yet been ascertained. I know of one case, where it was used as an external casing about seventy years ago, and it has now become so hard and compact as to render it almost impossible to doubt its continued durability. I remember, too, that about a year-and-a-half ago, in clearing a site for some new buildings, I had to remove a balustrade which had been put up about fifty years before. The capping of this balustrade, which had been executed in Bath stone, was in a most deplorable and dilapidated condition, but the ballusters (formed of grey stone lime, and rather fine, but very sharp silicious sand) were, in all respects, quite sound and perfect, exhibiting not the smallest approach to decay or disintegration; indeed, nothing but the fact of their being hollow, which was disclosed on their removal, would have convinced the workmen that they had not been carved out of some hard and compact stone.

In the very interesting paper on the Brick Churches of Germany, which was read here some time since, it was stated, that the mortar used in their construction, after the lapse of more than 500 years was so hard as to be capable of receiving a polish like marble. This, although a remarkable, is by no means a singular instance of that durability which judiciously formed compounds of lime and sand do undoubtedly possess; and it is on account of the abundant evidence which exists of their power of resisting atmospheric influences, that I have hitherto given them the preference over all other kinds of artificially-formed materials which have been used for covering the exteriors of buildings.

It was my intention to enter, at some length, into the respective merits of the blue lias and the grey stone limes; but finding it impossible to introduce this and other subjects connected with them in the compass of a single paper, I have been obliged to reserve the consideration of them for some future opportunity, when I may, perhaps, trespass again upon your attention.

Remarks.—In the discussion which followed, Mr. Francis expressed his regret that the paper just read contained matter not quite germane to its subject, which he considered to be one of great practical importance, as the employment of stucco must occasionally very properly take place. He then proceeded, at some length, to vindicate architects of the present day from the charge of servilely copying the buildings of the middle ages, which had been advanced by Mr. Knowles, and observed that the charge of want of novelty and of copyism applies to those who affect the classic styles, rather than to those who try to follow the spirit of mediæval architecture. Recurring to the subject of cement—he held it to be perfectly legitimate to apply it to cover a plain surface; but he considered it a material quite inadequate for the purpose of minute and elaborate design in ornamental work, which, when executed in it, must want the freedom of touch and the artistic feeling belonging to the chisel. Increased knowledge of the subject of building stones may enable us, eventually, to render the least enduring of them impervious to water, by injection of a fluid, or other means by which their natural defects may be overcome; but he felt assured, that we shall never emulate the buildings of the middle ages, nor discover a new style, by introducing in minute decoration the material so highly approved of in the paper.

Mr. Knowles explained that reference had been made to designs on the walls, solely for the purpose of illustrating the enduring quality of stucco in an unusually exposed situation—that he himself felt the evils of which he had complained, and did not profess to be free of them—but he thought, that if the talent which had been recently brought to bear upon mediæval architecture, had been directed into a more useful channel, greater progress might by this time have been made towards a style creditable to the age in which it was introduced.

Mr. G. G. Scott thought the evils complained of arose, not from a *want* of knowledge, but from its too extensive character; and and that we are acquainted with so many styles, that we do not know which to select. Classic architecture, after having had some three hundred years to develope itself, had, in many instances, degenerated into the state complained of. Without, in any way, retrograding to the manners and customs of five centuries ago, the remedy would be the introduction of a style capable of great development, which, if properly carried out, would, he believed, be found more adapted to the wants of the present day than any modification of the classical style. Without objecting to the use of plaster in proper situations, he certainly held the use of Roman cement to be destructive of the true character of art, by assisting in the imitation of other materials, and thus producing false appearances. The charge of copyism he repudiated altogether: what they did attempt by the study of ancient examples was to catch their spirit, and they were encouraged to proceed, by observing the progress made year by year, which showed that the revival had given greater proofs of vitality than architecture of an exclusively classical character had given during three centuries.

Mr. Knowles considered that a building cased with stone presented an appearance equally false as one covered with cement. No mediæval erections were, in his opinion, superior to the upper portion of the steeple of Bow Church, nor is there a structure in the world so exquisite as the outline of St. Paul's.

Mr. Donaldson, Hon. Sec. F.C., said, that, æsthetically speaking, stone must be considered preferable to stucco, on account of its greater beauty and variety of tint, while the jointing given to cement, in order to make it imitate stone, produces evidently a false appearance. He then pointed out the superiority in effect and appearance, which a figure executed in marble possesses over a cast in plaster, and demonstrated that this superiority is due to the inherent beauty of the material, and not to the mere circumstance of the marble being the more costly in point of expense.

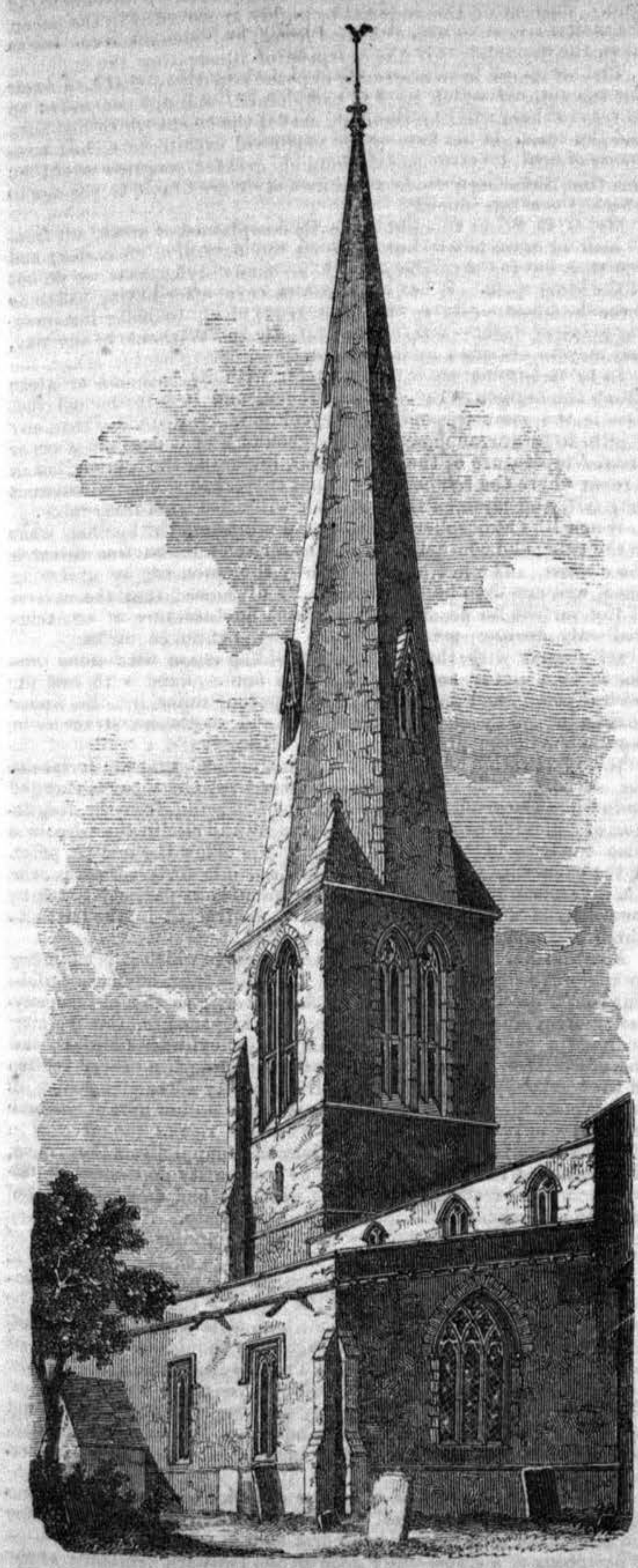
An observation by Mr. Scott, that there is more copyism in the details of Sir Christopher Wren's works than in most Gothic buildings he was acquainted with, called forth the expression of a directly contrary opinion from Mr. Billings, who also took the opportunity to dissent from a statement made at the last meeting, that all the Scotch castles might be placed within the walls of one Welsh castle. In support of his counter-statement, Mr. Billings gave instances of the extent of ground occupied by the castles of Edinburgh and Stirling.

The President having pointed out the advantages arising from meetings such as the present, in eliciting discussion on useful topics, a vote of thanks was then passed to Mr. Knowles, and the meeting adjourned.

STANION CHURCH, NORTHAMPTONSHIRE.

There is a range of churches along the northern border of Northamptonshire, whose detached position renders them less known than their merits deserve. Though somewhat plain in their general aspect, there is a dignity of proportion, and stateliness of outline very satisfactory. Of these may be enumerated Cottingham, Brampton, Desborough, Loddington, Corby, and Stanion. The latter, which may be taken as a sample, is remarkable for its slender and unusually lofty spire. Many portions of the church exhibit portions of early work, and others which, upon examination, prove to be of much later date, are nevertheless *in character* correspondent with these.

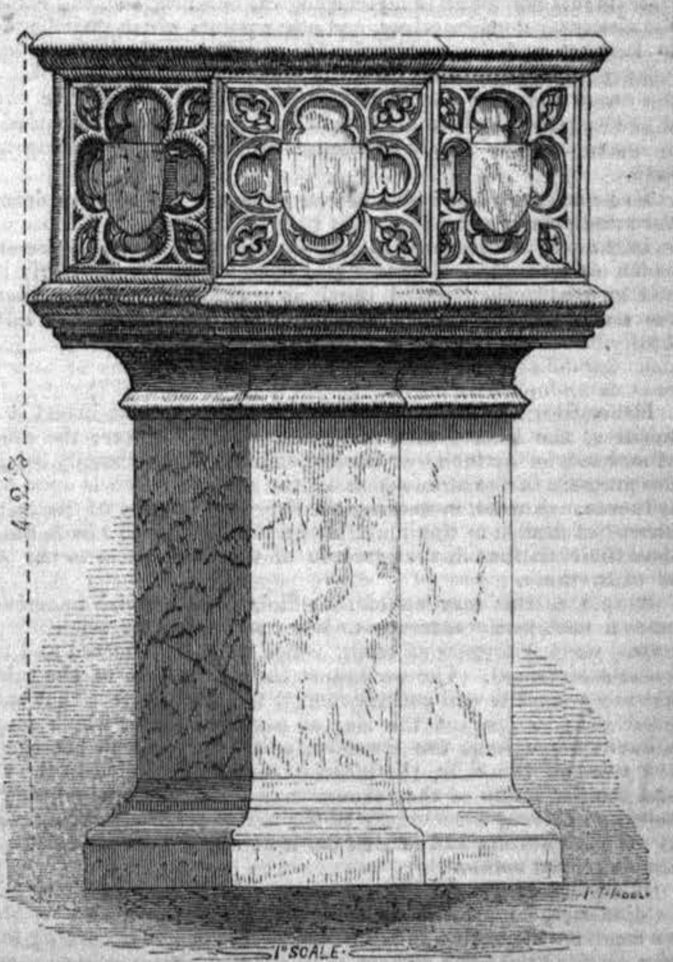
The chancel has some very good windows, with incipient tracery in the heads. The aisles and clerestory are mostly Perpendicular, and do not call for particular notice. The long double belfry lights in the tower, with their transoms, and the small buttresses (attached only to the western corners), will be observed as peculiar.



STANION CHURCH, NORTHAMPTONSHIRE.

FONT, WESTMINSTER ABBEY.

Among the various improvements made in the Abbey by the Dean and the architect, Mr. G. G. Scott, that of opening up a view of the west window of the south aisle and the font by the removal of the modern monument standing under the side arch of the south-west tower, although not the greatest, is by no means the least effective,—the long perspective view down this most exposed aisle being now seen in its full extent. A fine screen, of Perpendicular date, was found behind, and totally obscured by the monument now removed. In the space under this tower the font was placed, and seems to have been, from its out-of-the-way position, quite overlooked,—this being, as far as we are aware, the only representation of it ever published. The base to the neck mould is modern, and may have been a poor copy of what the original was. The shields have been painted, small particles of which yet remain; and the quatrefoils probably also. In the same place is a seat, of about the date of 1640, bearing a remarkable resemblance in the ornaments of the panelling on the back of the pulpits to be seen at Wensington and Aveley, Essex. On the bottom of the plinth stones to screen remains the working drawing of the section of the mullions above it: how they managed to work from it is rather difficult to say. If those men who think that Gothic architects only copied each other in any one style, were to compare this screen with those of Abbot Islyp's Chapel, that behind the altar, Henry V. Chantry, and Henry VII. Chapel together, and see the spirit of each designer self-evident in his own work, they would learn a lesson which might do a little towards preventing their setting themselves up as critics on things which they are supremely ignorant of: rendered so from the want of energy enough to make themselves acquainted with the subject on which they would treat; and so, like tall chimneys, can do nothing more than make a great smoke.



FONT, WESTMINSTER ABBEY.

METEOROLOGY.

On the Instruments employed in Meteorological Observations.

By JOHN DREW, Esq., F.R.A.S.

THE noble mansion of Hartwell, situated in the fertile vale of Aylesbury, and at the foot of the Chiltern Hills—the stewardship of which is accepted by those who are anxious to resign one of greater responsibility—is not devoid of interest from its historical associations. Here in seclusion resided the last of the Bourbons who bore the title of "King of France." The visitor to Versailles will call to mind the "Jardin à la Hartwell," which bears testimony to the agreeable recollections of this temporary retreat that followed the recluse when the sequence of events had placed a crown on his head. In the spacious and elegant library, Louis XVIII. attached his signature to the document which restored him to the throne of his ancestors. With objects far other than political, a few lovers of science had assembled in this room, at the invitation of the present proprietor, Dr. Lee, on the 4th of April, 1850, for the purpose of taking into consideration the present state of meteorology, and of adopting such measures as might conduce to its advancement. The result of their deliberations was the formation of a society, to be called the "British Meteorological Society," of which Dr. Lee was appointed Treasurer, and James Glaisher, Esq., F.R.S., F.R.A.S. (of the Royal Observatory, Greenwich), Secretary. The second meeting of the Council was held on the 7th of May. Within a month the Society has numbered ninety-five members, has elected as President, S. C. Whitbread, Esq., F.R.A.S., as Vice-Presidents Lord Robert Grosvenor, M.P., Hastings Russell, Esq., M.P., General Sir Thomas Brisbane, K.C.B., F.R.S., and Luke Howard, Esq., F.R.S.

Trusting that this movement will give an impulse to the study of atmospheric phenomena, and anxious, as one of the original members of the Council, to promote its objects, I avail myself of your offer to discuss in a popular manner the construction of those instruments employed in meteorological observations, the value of the observations themselves, and other points which may be likely to interest and draw attention to a science which is yet in its infancy—a science which calls upon all who imbibe the vital air, the *lumen spirabile cœli*, to co-operate in ascertaining the effects it produces on our sanitary condition: its powers as the medium of conveying the deadly pestilence or the health-inspiring antidote.

To promote this desirable object, it is my intention to describe the principles of construction of such instruments, and those only, as may assist a labourer in this ample field in contributing his share to the accumulation of phenomena from which we may fairly hope will be eventually deduced the laws regulating the atmosphere—the source of life and support to every member of the human family.

I.—*The Barometer.*

Fill a glass tube 32 inches in length with mercury, invert it in a vessel of the same liquid, and you have a barometer: the column of mercury in the tube will descend until its weight exactly balances the pressure of the atmosphere on the surface which is open to its influence. A scale, measuring the height of the top of the column above the surface of the liquid in the vessel, will show from time to time the variations in the pressure of the air vertical to the place of observation.

Simple as this may appear, we find, when we wish to arrive at results sufficiently accurate to be of any value for scientific purposes, various sources of error, which must be detected and their value ascertained. The vacuum at the upper part of the tube, if the instrument is well constructed, is the most perfect that can be produced; to prevent the rise of particles of air which may be diffused throughout the mercury, or may have been attached to the sides of the tube, the mercury should be boiled in the tube, and the perfection of the vacuum may be tested by inclining the tube and driving the mercury to the closed end, on striking which it will give a sharp and sudden tap if no air or moisture exist above the mercurial column.

If a piece of glass tube, not more, we will suppose, than ·4-inch in diameter, be inserted in water, the water will rise within it by capillary attraction to a height greater or less according to the size of the tube—the surface of the water within being concave: on the contrary, if the same tube be plunged into mercury, it will repel the metal all around, and the surface of the mercury within the tube will be convex, the top of the curve being depressed below the level of the liquid in the vessel. Now, unless the tube of the barometer is so large* that the the capillary attraction may be disregarded, it is evident that a correction must be applied to the observed height of the mercury in the barometer to reduce it to the true. This correction is always +, and is usually determined by the maker: if it be not, it may readily be obtained from tables when the diameter of the tube is known.

The scales of barometers adapted to scientific use are of brass throughout, extending from the cistern to the top of the tube: an increase of heat will be followed by an expansion both of the mercury and the scale. If the two metals expanded equally for equal increments of heat, no error would arise; but mercury expands more than any other metal known. Now supposing the atmospheric pressure to remain the same, but that the temperature has risen within a given period from 40° to 60°, the index would show (at a height of about 30 inches) a rise of 0·054 inch, which would be due not to increased pressure, but to the excess of the expansion of the mercury over that of the brass scale. It has been agreed to reduce all observations to a standard temperature, viz., 32 degrees of Fahrenheit—the freezing point of water—and for this purpose corrections are tabulated, and may be obtained by inspection.

In most barometers a thermometer with its bulb in the cistern shows the temperature of the mercury, and it is presumed that this is the same throughout the column. Sir John Herschel† objects to this arrangement on the ground that it does not give the mean temperature of the whole mass, including the column; but in a room where the temperature is not subject to sudden changes, it may fairly be assumed that no error will arise from this source.

When the atmospheric pressure diminishes, the mercury sinks in the tube, and consequently causes a rise of the surface of that in the cistern. The height measured by the scale, supposing it to be fixed, will not then be the true, as its divisions presume the level of the surface to be constant and not fluctuating—in fact, there will only be one point at which the measured distance will exactly agree with the real distance of the top of the column from the surface of the mercury in the cistern. This is termed the *neutral point*, and is ascertained experimentally by the maker during the progress of construction, and engraved on the scale, together with the proportion between the area of a section of the tube and a section of the cistern. It is evident that the surface of the mercury in the cistern will be lower than the zero point of the scale when the reading is above the neutral point, from the abstraction of a portion of its contents to supply the rise in the tube; and that it will be higher when the reading is below the neutral point. If the capacities be as one to forty-two, one forty-second part of the difference between the neutral point and any particular reading must be added in the former case, and subtracted in the latter, to obtain a corrected height.

Mr. Glaisher is not friendly to barometers to which it is necessary to apply the capacity correction. The glass tube, having a certain thickness, dips, of course, into the cistern: as the cistern gets fuller from a decrease in the atmospheric pressure, the mercury encloses a greater portion of this hollow cylinder of glass, and therefore rises higher (*i. e.* the surface approaches nearer the top of that in tube) than is shown by the capacity correction, which, as we have seen, only compares the area of the hollow part of the tube with that of the cistern. Again, when the rise of the mercury in the tube from increased pressure, draws the supply from the cistern, the surface is reduced in height by a quantity dependent on the volume of the section of the tube which it had enclosed, beyond what the correction for capacity would indicate. Nor is it an easy matter to calculate the effect which these annulus-like sections of the glass tube would produce on the readings of the barometer at different heights. He has, in consequence, superintended the construction of barometers in which the capacity correction should be superseded, at a very reduced price; and, as it is of importance that all observers who communicate with him should be possessed of instruments which should give uniform results, I shall describe the construction more at length. They are made by Barrow, of Oxenden-street, of whom they may be procured, price 7*l.* 7*s.*, and are all compared with the same standard by Mr. Glaisher himself, who supplies the results with the instrument when it is sent out into the world.

The cistern consists of a hollow cylinder of glass closed by a leathern bottom. A small index points downward towards the surface of the mercury, and the first step in taking an observation is by means of a screw which acts on the leathern extremity of the cistern, to adjust the level of the mercury until it exactly touches

* The diameter of the tube of the Greenwich standard is 0·565 inch; the correction for capacity is 0·202 inch.

† 'Admiralty Manual of Scientific Enquiry.'

the ivory point; the same action either raises or depresses the column of mercury, and, as the extremity of the ivory point is the zero of the scale, the reading will show the real height of the mercurial column above the surface of the liquid metal in the cistern, subject to only two corrections—viz., that of temperature and capillary action. The barometer is attached to a mahogany slab, projecting forward about two inches, and is free to turn on its axis in any direction. In reading off the scale a moveable ring is made to form a tangent to the curved surface of the mercury in the tube, a piece of white paper to reflect the light being placed behind it; with very little trouble the temperature and capacity correction may be combined in one, together with a small zero correction to reduce it to the Greenwich standard. When a table is thus formed, the absolute height of the barometric column may be ascertained from the reading by the application of one correction only, and that with the accuracy which has hitherto been attained by standard barometers at three times the price. As Mr. Barrow makes twelve of these at the same time, there is a fair chance of their readings being identical; and this is reduced almost to a certainty by the pains which Mr. Glaisher takes in comparing them with the same standard, and supplying the zero correction, which is never more than a few thousandths of an inch.

An example from a series of comparisons, lately taken with a barometer by Newman (very excellent of its kind), to determine its zero correction, and one of this construction, will show how much labour is saved in the reduction of observations taken by this improved instrument.

Newman's.		*Barrow's.*	
29·375	reading of the scale	29·376	
—·018	capacity	—·051	temperature + capillarity
29·357		29·325	corrected height
+·032	capillarity		
29·389			
—·064	temperature		
29·325	corrected height		

With some labour it would be possible to combine all the corrections for Newman's barometer in one—a plan I am about to adopt for the reduction of three years' observations with the instrument which was made purposely for me. In lieu of the glass cistern and leather bag, a double iron cistern, with a solid bottom, is introduced; and, with great simplicity, the mercury is secured for travelling by stopping off the greater portion after the instrument is inverted. It has accompanied me several hundred miles, and, without requiring special care, has returned uninjured. I have applied it to the purpose of measuring heights with great success, and have the utmost confidence in its indications.

II.—*Dry and Wet Bulb Thermometers.*

To render observations of the temperature of different places of any value to science, the instruments employed should be of the most accurate construction—the indications of the thermometers, for example, should be worthy of reliance to the tenth part of a degree: it is difficult, but not impossible, to attain to such accuracy. Out of twenty-five thermometers made for Mr. Glaisher, in 1843, by Watkins and Hill, twenty of them agreed within one-tenth of a degree at every part of the scale—the extreme difference between the readings of the remainder was half-a-degree. In his experiments on the radiation of heat from the earth at night (Phil. Trans., Part II., 1847) he mentions his possessing at one time upward of fifty instruments, whose extreme difference of reading from the standard was a constant quantity of half-a-degree in one thermometer, and of 0·2° in three others, the remainder being absolutely free from error.

These facts are mentioned to show the possibility of obtaining perfect instruments, but especially as a caution against the purchase of thermometers which have not been tested, or whose performance has not been guaranteed by a maker of high character: it is evident that no comparison of the mean temperature of different places can be made with instruments whose errors are not reduced within very narrow limits. Consideration of certain sources of error in constructing thermometers will at once show that those exhibited in shops, and sold for a trifling sum, have the name by courtesy and not by desert. To ensure delicacy in the construction of a thermometer, many niceties demand attention—two especially may be worth mentioning.

1. The bore of the tube should be uniform throughout: if it be not, the length of the degrees will not be the same at every part of the stem.

2. The observer should be fully persuaded of the accuracy of the scale which is adapted to the instrument, both as regards the zero point and the uniformity of the divisions. The zero point is ascertained by plunging the thermometer into melting ice, when its reading ought to be 32°. But it is a singular fact, that this zero point may be found to change, and hence it should be tested from time to time, and an index error allowed should any alteration have taken place. The thermometers used by the observers whose returns are published quarterly by the Registrar-General, have, for the most part, been examined by Mr. Glashier, and compared with a standard; and thus, as far as possible, uniformity of result is provided for: a character is given with the instrument, consisting of a series of comparisons with the standard, which is thus accomplished. The two thermometers are plunged into water of the temperature of the highest reading of the one whose character is the desideratum, and a series of comparative readings is taken as the temperature lowers. The differences will supply corrections to be applied at the various temperatures to reduce the readings to the standard; but in those supplied by Barrow, after Mr. Glashier's comparison, the differences are so minute that they may be safely disregarded in practice.

The wet and dry bulb thermometers are simply two thermometers side by side, which are presumed under the same circumstances to give similar indications. The dry thermometer, of course, shows the temperature of the air; the wet thermometer has its bulb surrounded with muslin, and from it lead a few inches of lamp-wick into a small vessel of water: the reading of this latter will in general be below the dry, and a comparison of the two will supply data for ascertaining the hygrometric state of the atmosphere. Without entering too far into the subject, a few words of explanation may be desirable.

Under general circumstances the atmosphere will take up the vapour of water: the drier it is the more rapidly will evaporation proceed, and the more slowly as its condition approaches that of complete saturation. When in that state no more moisture is capable of being held in suspension. Now, as evaporation proceeds, heat is absorbed by the conversion of the water around the bulb of the thermometer into vapour, and the mercury in the wet bulb will fall a greater or less number of degrees according to the dryness of the atmosphere. When the air is saturated, the readings will be the same. In Mr. Glaisher's 'Hygrometrical Tables' the subject of the wet and dry bulb thermometers is fully discussed, and, by their assistance, various interesting particulars may be deduced from the simple record of the different readings of the two. The most important of these deductions is the temperature of the dew-point, or that degree at which the atmosphere will part with its moisture, or will be cooled down to the point of saturation. The capacity of air for holding aqueous vapour in suspension diminishes with the abstraction of heat. The dew-point is that degree of temperature at which saturation is attained and moisture deposited. The difference between this and the temperature of the air has been investigated, and formulæ have been given by it which may be deduced from observations with the wet and dry bulb thermometers; but in Glaisher's 'Hygrometrical Tables' the dew-point may be found at sight from the readings of the wet and dry bulb; and I believe I am correct in stating that these results have been obtained from observation and not from theory.

The elegant hygrometer of the late Professor Daniel gives the dew-point by inspection; but, as it is attended with some inconvenience and expenditure of time, it has not come into general use. Many observers, like myself, occasionally verify, by means of simultaneous observations with it, the deductions from the dry and wet bulb thermometers.

The phenomenon of the dew-point may be illustrated by reference to the affairs of common life. A bottle of wine, to be rendered more agreeable, has been iced before its appearance in the dining-room. You will find that the bottle will be covered with a coating of dew the moment it enters the room; the temperature of its contents being far below the point of saturation, the watery vapour from the atmosphere will be condensed on the surface.—I visited some time since the observatory of a distinguished astronomical friend—every instrument in it was streaming with moisture. "The great drawback to my position," said he, "is the neighbourhood of yonder piece of water—see the effect." Upon inquiry, I learnt that, on the preceding evening, the observatory had been open; the instruments had been cooled down to the night temperature, and the day chancing to be much warmer than usual, they had not had time to get heated above the temperature of the dew-point, and

the deposition of moisture was the result—a cause entirely distinct from the one alleged.

I have a building detached from my own residence, which for some short time last Christmas was left without a fire. On my entrance one morning, which happened to be warm after a very cold night, I found the walls covered with moisture: they had, in in fact, retained the temperature of the night, and the moisture was due to their not having acquired sufficient heat, in the short space of time elapsed, to exceed the temperature of the dew-point; moisture, therefore, could not but settle on them, which disappeared as soon as they had attained a degree of heat rising above it.

III.—*Register Thermometers.*

As it is not my intention to enter upon the theory of atmospheric phenomena, which might perhaps form the subject of a future paper, I must proceed to describe another necessary adjunct to a meteorological apparatus, namely—the Register Thermometer.

Automatic registration of atmospheric phenomena has engaged for some time the attention of scientific men. At the observatory of Brussels, M. Quetelet pointed out to me an elegant contrivance, by which a thermometer was made to record its own variations. It was suspended on its centre of gravity, so that at the freezing point it should hang perfectly horizontal. At any degree of heat above 32° Fahrenheit, or the zero of Reaumur, the expansion of the mercury caused a depression of the end of the instrument the farther from the bulb; whereas, below the freezing point, the metal would retreat towards the bulb, and that portion of the tube would be the heavier. The instrument was connected in an ingenious manner with a system of levers, one of which moved a black-lead pencil, which inscribed the variations of heat on a sheet of paper connected with clock-work, by which it was advanced equal spaces (about one inch each per hour), a new sheet being supplied every day. These sheets gave the minutest variation in the temperature during the twenty-four hours.

For the last two or three years the magnetical, barometrical, and thermometrical observations have been registered at Greenwich by the application of photography. A lamp directs its light to the instrument, which light is intercepted by the mercury, and prevented from leaving a trace on properly prepared photographic paper placed behind. This paper is wound on a cylinder, which is turned round by clock-work, and its indications form an accurate register of the changes which may have taken place. Mr. Brook received from Government the sum of 500*l.* for the skill and labour bestowed on bringing this method of registration to perfection. The members of the British Association for the advancement of Science will call to mind his papers on the subject, which he has moreover fully discussed in the 'Philosophical Transactions.' From the Greenwich Meterological Observations for 1847, the following account of its especial application to the dry and wet-bulb thermometer is extracted:—

"These thermometers are mounted under a shed 10 feet square, standing upon posts 9 feet high, and the centres of the bulbs are 4 feet above the ground. The bulbs of the thermometers are very large, being cylinders about 8 inches long, and 0·4 inches internal bore. The fluid is quicksilver. One of the thermometer bulbs is covered (in the usual way) with muslin, which is charged with water by capillary passage along lamp-wicks, connected sometimes with one and sometimes with three cisterns of water. There is a coarse screw-motion for raising or depressing the thermometer-frames, so that each can be placed in such a position with regard to the photographic paper that the temperature shown by the thermometer may be recorded upon a convenient part of the paper. The thermometer-frames are covered by plates having longitudinal apertures, so narrow that any light which may pass through them is completely, or almost completely, intercepted by the broad flat column of quicksilver in the thermometer-stalk. Across these plates a fine wire is placed at every degree; and at the decades of the degrees, and also at 32°, 52°, and 72°, a coarser wire is placed. A camphine lamp (which has however been lately displaced for gas mixed with the vapour of coal naphtha) is placed near to each thermometer, and its light, condensed by a cylindrical lens whose axis is vertical, shines through the thermometer-stalk above the surface of the quicksilver, and forms a well-defined line of light upon the cylinder of paper which is close to it, parallel to the axis of the cylinder. As the cylinder of paper revolves under this light, it leaves a broad sheet of photographic trace, whose breadth (in the direction of the axis) varies with the varying height of the quicksilver in the thermometer-tube. But the light is intercepted by the wires placed across the tube at every degree; and there are, therefore, left upon the paper corresponding lines, in which there is no photogenic action." It is found that the application of photographic registration has enabled two observers to record more valuable observations than four were able to do before its introduction.

Private observers, however, cannot be expected to procure the costly apparatus necessary for these elaborate records. The maximum and minimum thermometers invented by Dr. John Rutherford, and described in the 'Edin. Phil. Trans.,' Vol. III., will enable them to record the greatest heat during the day, and the least during the night, with great certainty and very little trouble. The maximum thermometer is mercurial, and the tube is in a horizontal position; the mercury, as it expands, drives before it an index of steel, which, as the mercury contracts, is left at a point which indicates the greatest degree of heat attained. This thermometer is usually read at 9 A.M., and the index is brought to touch the mercury in preparation for the next day, either by inclining the tube, or by means of a magnet if it does not move freely. In some maximum thermometers a small piece of enamel is introduced between the index and the mercury, to prevent adhesion between the two metals, whereby the index would be drawn back and the observation lost. The minimum thermometer is filled with spirits of wine; a small index of ivory lies in the spirit, and is drawn backward as the liquid contracts in cooling, for the last film of the column of spirit, from the attraction between it and the interior of the tube, is sufficient to carry back the index towards the bulb: on expansion by heat the spirit, however, freely passes it, and leaves it to point out the lowest temperature attained. These thermometers should be compared with the dry bulb thermometers, by immersion in water as before described, and their readings, if they differ, registered and applied as corrections.

It has been usually supposed that a mean of the maximum and minimum readings for a month, divided by the number of days, would give the mean temperature for the month; but one of the contributions of Mr. Glaisher to meteorological science has shown that each month requires a certain quantity to be subtracted to arrive at the true mean.

He has also shown, that if to the mean of daily observations taken at any hour, certain quantities be added or subtracted, the mean temperature will be the result; it follows, that if the mean temperature thus deduced from one or more observations daily, agree with that derived for the corrected maxima and minima, such agreement is a proof of the excellency and a test of the accuracy of the whole series. (See the 'Phil. Trans.', Part I., 1848.)

In illustration I subjoin the result of my observations for January, 1849:—

Mean of the 9 A.M. observations for the month	40·7
Tabular correction	+ 1·
Mean temperature for the month.	41·7
Mean of the 3 P.M. observations	44·1
Tabular correction	− 2·5
Mean temperature	41·6
Mean of the 9 P.M. observations	40·9
Tabular correction	+ ·4
Mean temperature	41·3

Mean of the above three results, 41·5.

Mean of the maximum readings for the month	45·1
Mean of the minimum readings	38·4
Arithmetical mean of these quantities	41·7
Tabular correction	− ·2
Mean temperature from the maxima and minima	41·5

which exactly agrees with that deduced from the observations at 9 A.M., 3 P.M, and 9 P.M., after the application of the proper corrections.

As this paper is devoted to the description of instruments and not to the theory of meteorology, I must forbear to enter further on these points: I have alluded to them sufficiently to show that there is a field of inquiry open for the curious and inquisitive, which will amply repay cultivation.

Some observers are in the habit of recording the highest reading of a thermometer exposed to the full force of the sun's rays. In this case the instrument is of glass, with the degrees marked on the tube itself, to prevent accumulation of heat, reflection, and

radiation from a scale of wood or metal. It should be suspended at such a distance from all buildings and from the ground, as should effectually guard it from interferences of this nature. It will be a matter of surprise to those who have not had experience in observations of this nature, to find how very few degrees a thermometer thus situated will rise above one in the shade.

IV.—*The Rain-Gauge.*

This instrument measures the quantity of rain that falls in any given spot. The principle of it is the following:—If we imagine the surface of the ground over which a shower of rain has passed to be perfectly horizontal and impervious to moisture, so that the whole quantity of water should be retained, it would cover the surface to a certain depth, which, measured in inches, would be the depth of rain which had fallen. In calculating this depth by means of the rain-gauge, we expose a small surface to the reception of the rain, and measure the depth of what it receives. A shower may, however, pass by it, and, although much may fall at no great distance, not a drop may reach the exact spot occupied by the rain-gauge itself. Hence, to obtain the exact amount of rain which falls in any given district, several rain-gauges should be dispersed in various parts, and the mean of the whole amount received would be the true quantity due to such locality.

In this busy world of ours, however, observers (most of whom have important business of their own) are generally satisfied with registering the amount of rain received by their own gauges at 9 A.M. every day; and with the imperfect results deduced from these registers we must be satisfied, until a more extensive love for science is created and the number of observers multiplied.

Rain-gauges are of various constructions. In some, a glass tube, divided into inches, proceeds from the bottom of the vessel in which the rain is received, and the amount having been read off, the water is discharged by a stop-cock, in readiness for the next day. In others, a float is elevated by the water, and the scale which is attached to it shows the depth of rain received.

Perhaps the most simple is the one which I have adopted, and which is never liable to be out of order. A circular copper funnel, 12 inches diameter, is connected by a pipe with a vessel capable of holding a gallon, or more. To the bottom of this vessel is attached a stop-cock, by means of which the rain is drawn off and measured in a graduated glass cylindrical jar. Now, if a represent the diameter of the receiving vessel, and b that of the jar, c the depth of rain in the vessel, and x the required depth of the glass jar to measure such amount, then, since area, multiplied by the depth, gives the volume—

$$\cdot 7854\, a^2 c \;=\; \cdot 7854\, b^2 x; \qquad \text{or, } a^2 c \;=\; b^2 x.$$

Now, suppose the diameter of the glass jar to be 2 inches, and it is required to find what the depth of the jar will measure ¼-inch, we have—

$$12^2 \times \cdot 25 \;=\; 2^2 x; \qquad \text{or, } x \;=\; 9.$$

Nine inches of the jar, 2 inches in diameter, will therefore measure one-quarter of an inch of rain, received by a surface 12 inches in diameter. One twenty-fifth part of nine inches will consequently measure one-hundredth of an inch; and the thousandths may be estimated.

The rain-gauge should be only a few feet from the ground, and in every case its height should be stated, as it is invariably found that more rain is received near the surface than at a superior elevation. Indeed, it should be agreed upon by observers that their gauges should all be at the same height, and all equally free from the interference of buildings or trees. Till some rule of this kind is adopted, we are not in a position to compare accurately the quantity of rain which falls in different districts. At Greenwich there are several rain-gauges at different heights above the ground.

The following table will show the differences between the quantity of rain received by them in 1846 and 1847:—

Height above the ground. ft. in.	Inches of rain received in 1846.	Inches of rain received in 1847.
50 0	13·46	7·12
24 0	22·63	13·02
1 11	25·86	16·49
0 5½	25·29	17·61

V.—*The Wind-Gauge.*

The most simple instrument for ascertaining the force of the wind, and the one most likely to be made use of by the generality of observers, is that invented by Dr. Lind. It consists of a glass tube, about ½-inch in diameter, of a syphon-like form, one end being again bent at right angles to the general direction of the tube, so as to present a horizontal opening to the wind. The tube is half-filled with water, and the pressure of the wind on that portion directed towards it will drive the water up the other leg. A scale is attached, by which the force of the wind is ascertained; and the whole turns freely on a vertical axis, so that the mouth may always be towards the quarter from whence the wind blows. The following table shows the pressure per square foot for the indications of the scale.

Not having a convenient place to fix this instrument, for it should be far above the interference of buildings or trees, I generally estimate the force of the wind from the knowledge gained by its occasional use. Many observers do so without any reference to the wind-gauge at all; and from following the directions in the table subjoined, they cannot be far out. A calm is universally represented by 0; a hurricane, or violent gale, by 6.

TABLE.—*Showing the Force of the Wind on a Square Foot for different Heights of the Column of Water in "Lind's Wind-Gauge."*

Inches.	Force in lbs.	
6	31·75	A hurricane
5	26·04	A very great storm
4	20·83	A great storm
3	15·62	A storm
2	10·42	A very high wind
1	5·21	A high wind
·5	2·6	A brisk gale
·1	·52	A fresh breeze
·05	·26	A pleasant wind
0·	0·	A calm

It now only remains for me to speak of the position of the instruments which I have enumerated.

The barometer may be placed in a sitting-room; for as the correction for temperature is always applied, the degree of heat will produce no difference in the results. It should be so situated as regards light that it may be easily read off. To support the wet and dry bulb and register thermometers, I use a stand of such a height as to allow the bulbs to be about four feet from the ground; the top sides and back of this stand are covered with an external case of wood-work, separated from the internal, which is of the same materials, by a vacant space of two inches, by which means a stratum of air, which is a bad conductor of heat, is always interposed; and the heat of the sun which shines on the outer case is prevented from reaching the inner compartment which contains the thermometers; they face the north, and are placed so that they cannot be affected by the radiation of heat from neighbouring walls or buildings, and the sides of the stand project so as to protect them from the sun when his azimuth is north of the east or west. A series of holes, not however opposite to each other, is bored in the inner and outer case, which admit the air, but not the rays of the sun. Mr. Glaisher has shown, and his result may be verified by experiment, that the indications both of the wet and dry thermometers will be the same whether they are exposed to a draught of air or protected from it.

The following works must be procured by those who wish to become observers:—Glaisher's 'Hygrometrical Tables,' which treat of the wet and dry bulb thermometers, and the deductions from observations made with them, price 2*s*. 6*d*.

The 'Report of the Committee of Physics of the Royal Society;' here may be found a good table for the temperature correction, 1*s*.

Prices of the instruments enumerated: barometer, 7*l*. 7*s*.; wet and dry bulb thermometer, 2*l*. 2*s*.; register thermometers, 2*l*. 2*s*.; rain gauge, 2*l*, 10*s*.; wind gauge, 1*l*. 5*s*. Mr. Clark, 13, Moorgate-street, will supply paper ruled in such a manner as to afford a convenient space for the record of all the observations.

I have thus given a popular view of the construction and use of the most available meteorological instruments, and shall be happy if my introduction of the subject should lead to a large increase of the number of observers. About forty at present send in regular reports to the Registrar-General; but let us hope that the present movement, of which the formation of the British Meteorological Society is the indication, may enlist ten times that number, and that the labours of its members may tend to raise the study of atmospheric phenomena to a position equal to that held by sciences which have originated in our time. The observations require care, perseverance, and a desire to promote the interests of science.

We know not, perhaps, the exact end which may be attained by our individual labour; but hereafter it will be a source of satisfaction to consider that we have been humble pioneers in a region which may be productive of benefits at present unimagined and unforeseen.

Southampton, May 18th, 1850.

REGISTER OF NEW PATENTS.

RAILWAY CHAIRS.

JOHN TORKINGTON, of Bury, Lancaster, railway contractor, for "*certain improvements in the construction of chairs for railways.*"—Granted October 12, 1849; Enrolled April 12, 1850. [Reported in *Newton's London Journal.*]

The object of this invention is to obviate the serious inconveniences which result from the yielding of the rails at the joinings or points where the different lengths of rail meet or cross, during the passage of trains over the same; and it consists in certain improvements in the chairs used for supporting such rails, whereby the patentee produces what he calls the "uniformly-supporting joint chair."—Fig. 1 is a longitudinal elevation of the improved chair; fig. 2 is a plan view thereof; fig. 3 is an end view; and fig. 4 is a transverse section taken at the centre of the chair. It

Fig. 1

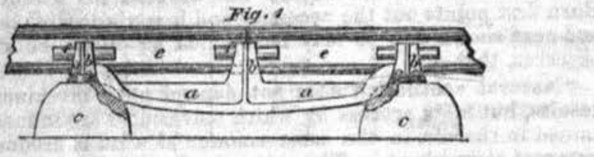


Fig. 2

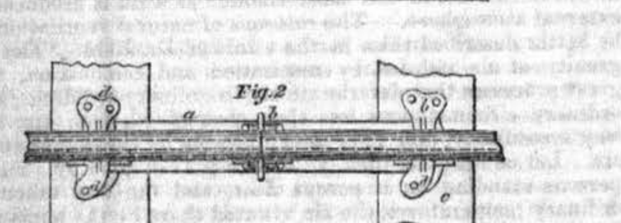
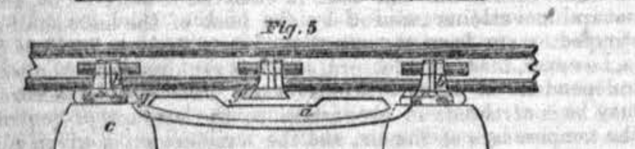


Fig. 4

Fig. 3

Fig. 5



consists of an iron rib or beam *a*, about three feet long, on the upper side of which three holders or chairs *b*, *b*, *b*¹, similar in form to the ordinary chairs, are cast; and the rib or beam rests at each end upon a transverse sleeper *c*, to which it is secured by spikes or trenails *d*, *d*. The top of the rib or beam serves to support the ends of the two adjacent rails *e*, *e*¹, which meet at the centre of the middle holder or chair *b*, and are secured there by the insertion of a key or wedge *f*; and similar keys or wedges are driven into the two end holders or chairs *b*, *b*: the bearing of the ends of the rails on the chair, which now seldom exceeds two inches, is thus increased to about eighteen; and there will consequently be a proportionate increase in the unyieldingness of the rails under pressure and in the steadiness of the carriages passing over them. This arrangement is stated to combine all the advantages of the longitudinal system of laying sleepers with those resulting from the employment of transverse sleepers or blocks. Instead of the holders or chairs *b*, being cast in one piece with the rib or beam *a*, they may be cast separately, and afterwards secured thereto by inserting their bases (which are suitably formed for the purpose) into dovetail recesses in the top of the rib or beam, and then driving in the wedges *g*. In place of only three holders or chairs being cast on or attached to the rib or beam *a*, the number may be increased to five.

BOILER TUBES.

JAMES BANNISTER, of Birmingham, manufacturer, for "*a certain improvement or certain improvements in tubes for locomotive and other boilers.*"—Granted October 12, 1849; Enrolled April 12, 1850.

The invention relates to manufacturing tubes suitable for locomotive and other boilers, by combining three tubes of different metals into one tube; and to a mode of manufacturing tubes of copper, brass, and other alloys of copper, suitable for the purposes of locomotive and other steam-boilers. In the first part of the invention for making each tube, three tubes of different metals are employed. First, a brass tube; second, an iron tube; and, third, a copper tube, are placed one on the other, the brass tube being on the interior; the iron tube next; and the copper tube exterior; and in preparing such separate tubes they are made of such sizes that they will readily enter one within the other. Brazed tubes are preferred, because thin metal tubes for the purpose can be more readily obtained. Having placed the tubes one on the other, a slightly tapering mandril is introduced, and the combined tube drawn through a series of dies till they are closely combined; and as the tubes are employed in a soft or annealed state when put together, it has not been found necessary to anneal them afterwards between the successive processes of drawing, seeing that the extent of drawing down is but small. By this mode of constructing tubes for boilers the advantage is obtained of having the beneficial results consequent on using brass where the rush of the flame and products from the fire takes place, together with the advantage of having the copper next the water; and the whole stiffened by the use of iron; but when the fire is to act externally, then the order of arrangement is to be reversed.

The second part of the invention consists of new means of joining the seams of tubes made of copper or brass and other alloys of copper. The metal is to be bent over into the form of a tube, so that the edges come together, and then, by the edge of a triangular file remove the edges of the metal, so as to form as it were an angular gutter. The tube is then filled with sand, and the exterior covered with sand, leaving a gutter in the sand so as to increase the size of the gutter made by the coming together of the chamfered edges of the metal, and in this condition the tube is heated to a bright red heat. Melted metal (similar to that used for the tube) is then poured into the gutter, which will partially fuse the edges of the metal of the tube, and then the whole will set into a solid mass; and when the same is cold the projecting-ridge of metal at the seam is removed; and this is best done by passing it in contact with a circular saw. The tubes thus made are caused to pass two or three times through between grooved rollers, having a mandril in them, and then they are completed by drawing them through dies with a mandril, as when drawing other similar tubes for like purposes, and which is well understood.

MANUFACTURE OF STEEL.

JOSIAH MARSHALL HEATH, of Hanwell, Middlesex, gentleman, for "*improvements in the manufacture of steel.*"—Granted September 6, 1849; Enrolled March 6, 1850.

The invention consists in the application of iron, produced from iron ores without being brought to the state of pig or cast-iron, to the manufacture of steel, the iron so produced being manufactured by the process described, which renders it more suitable for conversion into steel than any iron hitherto made by the processes actually in use. The excellence of the steel depends upon the comparative purity or freedom from mixture with extraneous substances of the iron from which it is made. All iron made by smelting the ores of that metal in a blast furnace contains impurities, in consequence of the alloys formed between the fluid metal and the earthy alkaline or other extraneous substances contained in the ores, the fuel, and the matters used to flux the ores. These impurities can never be completely removed from the metal by the operations in use for converting the pig into malleable iron.

Any pure ore or oxide of iron from which the earthy or other extraneous matters can be easily separated by the mechanical operations of crushing, winnowing, washing, or magnetic attraction, may be treated in the manner the inventor proposes, but he prefers the magnetic ore of iron to all others. The ore is to be reduced to the state of grains, or even of fine powder, in order to facilitate the separation from it of the earthy or other extraneous substances; the pure ore is then to be reduced to the metallic state by any of the well-known processes for depriving the metal of oxygen, by acting upon it with carbon, or any other reducing agent

at a heat below that required to bring the metal to the fluid state. The metallic product obtained in this way, when operating upon a manufacturing scale, can never be obtained absolutely free from the last portions of earthy or other impurity, and always contains some portion of oxide of iron, which renders it quite unfit for conversion into steel of good quality, as it comes from the process of deoxidation without further treatment.

To make a perfect steel iron, the metallic product is taken as it comes from the process of cementation or deoxidation, and mixed with a small portion of oxide, or chloride of manganese, and a certain portion of coal or fir tar, or any cheap hydrocarbon or carbonaceous matter. The best results are obtained from the mixture of from one to three pounds of oxide or chloride of manganese, and from one to two gallons of coal or other tar to each one hundred pounds of deoxidated ore. The mixture of granular iron tar and manganese, resulting from this process, is heated in a suitable furnace; and when the iron is at a welding heat it is removed from the furnace, and subjected to the action of some suitable instrument of compression, in order to be formed into a solid bloom by any of the usual processes now in use. The bloom is then to be reheated and shingled, hammered, or rolled into bars in the usual manner. The bar-iron so produced is to be converted into steel by the well-known processes now in use, and its quality will be found superior to that made from the best iron hitherto procurable.

VITRIFIED BRICKS.

William Gilbert Elliott, of Blisworth, Northampton, gentleman, for "*improvements in the manufacture of bricks, tiles, and pipes, and other articles from plastic materials.* (A communication.)—Granted April 27; Enrolled May 27, 1850.

This invention relates to manufacturing bricks, tiles, pipes, and other articles, from clay, melted or fused, and run into moulds of the shape of the articles required to be produced. The clay, as it is dug from the pit, if dry, is conveyed to an air or blast furnace, wherein it is brought to a state of fusion, and then run into the moulds, which should be as close to the furnace as possible; for the melted clay should be introduced into the moulds at a high degree of heat; as it will not bear to be conveyed in ladles or run through troughs into the moulds. The moulds may be made of iron or other suitable material. The moulds may be carried to and from the furnace by an endless wire web or band, which moves beneath the furnace, and thus brings the moulds close to the opening from which the fused clay is discharged.

GLAZING CAST-IRON.

William Wyatt, of Waterloo Cottage, Oldswinford, Worcester, pump-maker, for "*improvements in coating the surfaces of pumps, pipes, cisterns, and other articles of iron.*"—Granted October 18, 1849; Enrolled April 18, 1850.

The improvement relates to coating cast-iron pumps, cast-iron pipes, cast-iron cisterns, and other articles of cast-iron, with a glass or glaze composed of lead, borax, and silex, combined in the proportion of three parts, by weight, of white lead (or one of red lead and two of white lead), two parts of borax, and one part of calcined flint, well mixed together and fused in a crucible, then run into water, and ground with water in a glaze-mill. When the mixture is thoroughly reduced, so that it will readily pass through a silk or lawn sieve, such as are used by china manufacturers, it will be ready for use: it is not absolutely necessary to fuse the materials, but it is better to do so. The glaze thus prepared being about the consistence of cream, is applied to the inner surfaces of the pump-barrels, pipes, and similar articles of cast-iron, by closing one end, introducing a quantity of glaze, turning the article round, so as to coat the interior uniformly with the glaze, and then pouring out the surplus. The interior of cisterns and like articles of cast iron is coated in a similar manner, by introducing a quantity of glaze and moving the article about in various directions until the interior is uniformly coated. In general it will only be necessary to scour and wash the surface previous to coating; but if the surface is much oxidised, it is requisite to subject the articles to a red heat, and, when cool, to scour them well with water. It is preferred to warm the metal before the application of the glaze, in order to facilitate the drying of the latter. The exterior surfaces of articles of cast-iron may be coated by dipping the articles into the semi-fluid glaze, or by applying the glaze thereto with a brush.

After the pumps, pipes, cisterns, or other articles of cast-iron have received a coating of glaze, they are to be subjected to a suitable temperature for firing the glaze and thereby causing it to adhere. This is effected by placing the articles in a kiln heated in such manner that no flame or sulphur shall come in contact with the articles. The heat is gradually raised until the glaze melts (which can be seen by taking out a brick from an opening in the kiln); and, so soon as the melting of the glaze takes place, the fires are drawn, and the articles are allowed to cool: when the articles have become cool, they are removed from the kiln, and are ready for use.

REVIEWS.

Practical Ventilation, as applied to Public, Domestic, and Agricultural Structures. By Robert Scott Burn, Engineer. Blackwood and Sons, Edinburgh and London. 1850.

The importance of ventilation in connection with sanitary progress is an admitted fact, that does not require us now to descant upon. What has to be considered is, how ventilation may be applied to buildings effectively and economically: it is to these considerations that the author has devoted his attention. Mr. Burn first points out the necessity and importance of ventilation; and next shows how it may be applied to public buildings, and observes, that

"Natural ventilation does not depend upon machinery for its results, but is 'a process by which movements are induced or sustained in the air, in the same manner as wind is produced in the external atmosphere.' The *rationale* of natural ventilation cannot be better described than in the words of Dr. Reid: 'The specific gravity of air vitiated by respiration and combustion, the two great processes that deteriorate air in ordinary buildings, is under ordinary circumstances less than that of common air: it gives way accordingly, and is pressed upwards by the denser and purer air. Let us imagine, then, an apartment occupied by a number of persons standing on a porous floor, and the roof taken off; at ordinary temperatures, the air, vitiated there by the human frame, requires no mechanical power to remove it. The superincumbent pressure is diminished by the expansion induced in the air as it is heated; but the external air is permitted to have free access below, as well as above, to the porous floor. Its power therefore preponderates, and an upward movement is the necessary consequence; which is accompanied by the introduction of fresh air and the removal of that which is vitiated. Here, then, is a species of natural ventilation. All that is essential is merely this, that the natural movements induced by the heat of the body shall not be stopped by any barrier opposed to them. An open roof and ceiling is, however, inadmissible: protection is required from the weather, independent of other arrangements. The opening, accordingly, may be contracted: in proportion to the amount of contraction, the temperature of the air, and the numbers on a given space, it now becomes necessary to increase the velocity of the discharge from the apartment referred to. To effect this, if a shaft or chimney be extended from any opening in or near the ceiling, the column of warm air which soon fills it increases its power; and unless an extreme number of individuals be crowded in the apartments, the shaft *is sufficient for all ordinary purposes.*'

"In ventilating buildings, two things should be borne in mind; and as upon the proper attention to these depends the success of the plan, particular attention should be taken to see them carried into effect. These are, the supply of the interior with fresh air, and the withdrawing of it when vitiated. And here we would request attention to the fact, of which the evidence of all experience goes to prove the truth—that no *foul air can by any possibility be extructed from the interior of any building, however well arranged the means to insure its exit may be, unless an ample supply of pure air is admitted.* In making provisions for the supply of pure air, due regard should be had to the source from which it is supplied. If much dust or extraneous mechanical impurities should be at the base of the building, or drains near to or passing through there, the air should be led from a distance from the ground....And in order to stop the ingress of all extraneous particles of dust, &c. through the ventilator, there should be stretched across the *inside* of the opening, sheets of very finely perforated zinc or horse-hair cloth. Where the air has to be led into the interior of a church, say to the passages, ventiducts must be employed to conduct the

air to the required place. These conduits may be made of zinc or iron pipes; but a cheaper mode is to make wooden boxes of sufficient size. To prevent the damp from affecting these, the outside should be covered with two or three coats of a composition of tar and sand (three of the former to one of the latter). The best place, in the generality of churches, to lead the air to, is the passages; and, indeed, in most other public buildings. The apertures at the place of ingress to the interior should be covered with cast-iron gratings. But in order to diffuse the air as much as possible in its passage through the gratings, along the under side of these, plates of zinc, with small perforations, should be fixed, or sheets of horse-hair cloth. For this purpose we would also recommend the adoption of "cocoa-nut fibre matting"—it is very cheap, porous, and can be made of any closeness of texture: it is becoming much used for the passages and aisles of churches. If used in this way, any species of grating, however rough, would do, as it would be hidden by the cloth laid above it. One thing in connection with the gratings should be borne in mind, that is, to have the apertures greater, at least equal in surface to those on the outside.

"The apertures for the admission of fresh air should be disposed at equal distances round the building, if possible on all sides, so that, from whatever quarter the wind blows, an aperture may be placed so as to receive its influence: not that the force of the wind is necessary, for air, as we have shown, will find its way wherever it is required, unless prevented; but in windy weather more air will be *forced* in, in a given time, than in calm weather. Having provided means for the admission of fresh, we will now direct attention to the means for withdrawing the foul air. The apertures for its escape should be placed in all cases at the highest part of the ceiling. If the nature of the building will admit of it, the area of the aperture should be distributed over the ceiling in more than one place. Supposing the area of aperture of a church is required to be 3 square feet—if three apertures of 1 square foot each, be placed along the roof at regular intervals, the building will be more speedily ventilated than if one aperture of 3 feet square was alone used."

In the next chapter the author explains how ventilation may be applied to dwelling-houses and shops, and describes several kinds of ventilators which are applicable to the purpose—such as Bailley's glass louvres, perforated glass, Dr. Arnott's valve, and Mr. Toynbee's suspension valve, consisting of a square iron tube, 3 to 6 inches square, and 4 to 6 inches long, with a piece of perforated zinc over the external orifice, and at the back a piece of oiled silk, which acts as a valve, so as to allow the warm and vitiated air to pass up the chimney, and to prevent any smoke entering the chamber.

Mr. Burn describes a method of ventilating a house by the staircase; it is simple, and appears to be very effective.

"In supplying fresh air to the lobbies, halls, or central staircases of large mansions, from which all the apartments are to be supplied, care should be taken to have the quantity sufficient in volume. It will materially assist the ventilation if the air is warmed as it is admitted. The air should be led to the floor of the hall, in which apertures may be made to allow it to pass through; or it may be taken to the back of the skirting, or beneath permanently fixed tables, the fronts of which should have plates of perforated zinc. If the staircase is provided with a skylight, this should be kept carefully closed; the desideratum, in such cases as we are now considering being to supply each apartment with means of withdrawing the used air, so as to draw their supply of pure air from the central magazine; not only ventilating themselves, but also the staircases, passages, &c., these being supplied with fresh air from the central magazine. If the skylight was left open, thus creating a powerful upward current, the flow of air into the apartments would be materially retarded, if not in some cases altogether stopped. There is one danger connected with this plan of supplying air to the apartments of large mansions, worth being noticed; this is if each apartment is not properly ventilated, the foul air from it will obtain access to the central magazine whenever the door is opened, its egress through such being easier—the air in the central magazine being thus contaminated. Again, some apartments may, from more powerful ventilating arrangements, draw their supply from another apartment; this shows the necessity of having the supply to the central magazine ample. If the mansion consists of many stories, each landing may be supplied with a separate supply of pure air, independent of the openings in the hall previously mentioned."

In the next chapter, Mr. Burn explains how ventilation may be applied to agricultural structures; and in the concluding chapter, various systems of warming of buildings, construction of fire-places, and smoky chimneys. Here we must stop, before we are tempted to make a few more extracts, as we have already intruded further than we at first intended upon the work.

A Rudimentary Treatise on the History, Construction, and Illumination of Lighthouses. By ALAN STEVENSON, M. Inst. C.E., Engineer to the Board of Northern Lighthouses. London: Weale. 1850.

IT must certainly be esteemed a great recommendation for this rudimentary treatise that it is written by the constructor of one of the greatest lighthouses in the world—that at Skerryvore. Mr. Stevenson is the author of a description of this work, and therein has laid the foundation of the present treatise, which applies to lighthouses generally those principles which were discussed before in especial reference to Skerryvore. Much space is given to the various systems of illumination adopted; and of the remainder of the book, although most valuable, it is so well known we are almost deterred from making a quotation. At all risks, however, we give some account of Skerryvore.

"The Skerryvore Rocks, which lie about 12 miles W.S.W. of the seaward point of the Isle of Tyree, in Argyllshire, were long known as a terror to mariners, owing to the numerous shipwrecks, fatal alike to the vessels and the crews, which had occurred in their neighbourhood. A list, confessedly incomplete, enumerates thirty vessels lost in the forty years preceding 1844; but how many others, which during that period had been reported as "foundered at sea," or as to whose fate not even an opinion has been hazarded, may have been wrecked on this dangerous reef, which lies so much in the track of the shipping of Liverpool and the Clyde, it would be vain to conjecture. The Commissioners of the Northern Lighthouses had for many years entertained the project of erecting a lighthouse on the Skerryvore; and with this object had visited it, more especially in the year 1814, in company with Sir Walter Scott, who, in his diary, gives a graphic description of its inhospitable aspect. The great difficulty of landing on the rock, which is worn smooth by the continual beat of Atlantic waves which rise with undiminished power from the deep water near it, held out no cheering prospect; and it was not until the year 1834, when a minute survey of the reef was ordered by the Board, that the idea of commencing this formidable work was seriously embraced.

"The reef is composed of numerous rocks, stretching over a surface of nearly 8 miles from W.S.W. to E.N.E. The main *nucleus*, which alone presents sufficient surface for the base of a lighthouse, is nearly 3 miles from the seaward end of the cluster. It is composed of a very compact *gneiss*, worn smooth as glass by the incessant play of the waters, and is so small that at high water little remains around the base of the tower but a narrow band of a few feet in width, and some rugged humps of rock, separated by gullies through which the sea plays almost incessantly. The cutting of the foundation for the tower in this irregular flinty mass occupied nearly two summers; and the blasting of the rock in so narrow a space, without any shelter from the risk of flying splinters, was attended with much hazard.

"In such a situation as that of Skerryvore everything was to be provided beforehand and transported from a distance; and the omission in the list of wants of even a little clay for the *tamping* of the mine-holes, might for a time have entirely stopped the works. Barracks were to be built at the workyard in the neighbouring island of Tyree, and also in the Isle of Mull, where the granite for the tower was quarried. Piers were also built in Mull and Tyree for the shipment and landing of materials; and at the latter place a harbour or basin, with a reservoir and sluices for scouring the entrance, were formed for the accommodation of the small vessel which attends the lighthouse. It was, besides, found necessary, in order to expedite the transport of the building materials from Tyree and Mull to Skerryvore Rock, to build a steam-tug, which also served in the early stages of the work as a floating barrack for the workmen. In that branch of the service she ran many risks while she lay moored off the rock in a perilous anchorage, with *two-thirds* of the horizon of *foul ground*, and a rocky and deceitful bottom on which the anchor often *tripped*.

"The operations at Skerryvore were commenced in the summer of 1838, by placing on the rock a wooden barrack, similar to that first used by Mr. Robert Stevenson at the Bell Rock. The frame-work was erected in the course of the season on a part of the rock as far removed as possible from the proposed foundation of the lighthouse tower; but in the great gale which occurred on the night of the 3rd of November following, it was entirely destroyed

and swept from the rock, nothing remaining to point out its site but a few broken and twisted iron stancheons, and attached to one of them a piece of a beam so *shaken* and rent by dashing against the rock as literally to resemble a bunch of laths. Thus did one night obliterate the traces of a season's toil, and blast the hopes which the workmen fondly cherished of a stable dwelling on the rock, and of refuge from the miseries of sea-sickness, which the experience of the season had taught many of them to dread more than death itself. After the removal of the roughest part of the foundation of the tower had been nearly completed, during almost two entire seasons, by the party of men who lived on board the vessel while she lay moored off the rock, a second and successful attempt was made to place a second beacon of the same description, but strengthened by a few additional iron ties and a centre post, in a part of the rock less exposed to the breach of the heaviest waves than the site of the first barrack had been. This second house braved the storm for several years after the works were finished, when it was taken town and removed from the rock to prevent any injury from its sudden destruction by the waves. Perched 40 feet above the wave-beaten rock in this singular abode, the writer of this little volume, with a goodly company of thirty men, has spent many a weary day and night at those times when the sea prevented any one going down to the rock, anxiously looking for supplies from the shore, and earnestly longing for a change of weather favourable to the recommencement of the works. For miles around nothing could be seen but white foaming breakers, and nothing heard but howling winds and lashing waves. At such seasons much of our time was spent in bed; for there alone we had effectual shelter from the winds and spray which searched every cranny in the walls of the barrack. Our slumbers, too, were at times fearfully interrupted by the sudden pouring of the sea over the roof, the rocking of the house on its pillars, and the spurting of water through the seams of the doors and windows, symptoms which, to one suddenly aroused from sound sleep recalled the appalling fate of the former barrack, which had been engulphed in the foam not twenty yards from our dwelling, and for a moment seemed to summon us to a similar fate. On two occasions, in particular, those sensations were so vivid as to cause almost every one to spring out of bed; and some of the men fled from the barrack by a temporary gangway to the more stable but less comfortable shelter afforded by the bare wall of the lighthouse tower, then unfinished, where they spent the remainder of the night in the darkness and the cold.

"The design of the Skerryvore lighthouse was given by the writer of this volume, and was an adaptation of Smeaton's Eddystone Tower to the peculiar situation and circumstances of the case at the Skerryvore, with such modifications in the general arrangements and dimensions of the building, as the enlarged views of the importance of lighthouses which prevail at the present day seemed to call for.

"The Skerryvore Tower is 138 ft. 6 in. high, and 42 feet in diameter at the base, and 16 feet at the top. It contains a mass of stonework of about 58,580 cubic feet, or more than *double* that of the Bell Rock, and not much less than *five times* that of the Eddystone.

"The mortar used at the Skerryvore was compounded of equal parts of limestone (from the Halkin Mountain, near Holywell, in North Wales), burnt and ground at the works, and of Pozzolano earth. The mixture was carefully beaten up to the required consistency with sea-water. All the joints of each course of the building were carefully filled with *grout*, which is cement in a fluid state.

"The entire cost of the lighthouse, including the purchase of the steam vessel and the building of the harbour at Hynish for the reception of the small vessel which now attends the lighthouse, was 86,977*l.* 17*s.* 7*d.*, the detailed items of which will be found in the Appendix to the *Account* of the Lighthouse already alluded to.

"In such a situation as the Skerryvore, innumerable delays and disappointments were to be expected by those engaged in the work; and the entire loss of the fruit of the first season's labour in the course of a few hours, was a good lesson in the school of patience, and of trust in something better than an arm of flesh. During our progress, also, cranes and other materials were swept away by the waves; vessels were driven by sudden gales to seek shelter at a distance from the rocky shores of Mull and Tyree; and the workmen were left on the rock desponding and idle, and destitute of many of the comforts with which a more roomy and sheltered dwelling and the neighbourhood of friends are generally connected. Daily risks were run in landing on the rock in a heavy surf, in blasting the splintery gneiss, or by the falling of heavy bodies from the tower on the narrow space below, to which so many persons were necessarily confined. Yet had we not any loss of either life or limb; and although our labours were prolonged from dawn to night, and our provisions were chiefly salt, the health of the people, with the exception of a few slight cases of dysentery, was generally good throughout the six successive summers of our sojourn on the rock. The close of the work was welcomed with thankfulness by all engaged in it; and our remarkable preservation was viewed, even by many of the most thoughtless, as, in a peculiar manner, the gracious work of Him by whom 'the very hairs of our heads are all numbered.'"

Architectural Publication Society. Illustrations, Part II. of Volume for 1849-50.

The part now before us includes Arcade, Mosaic Ceiling, Interior of Chapels, Chimney, Façade, Metal Work, Pedestal, Piazza, Pulpit, and Staircase, with thirteen plates. Most of the examples are Italian. The plate representing the interior of the Chapel of San Domenico at Bologna is coloured so as to give some idea of the picturesque appearance of the original building. The Mosaic Ceiling of the Sacristy of St. Mark's at Venice is a novelty, and it is likewise illustrated by an illuminated plate of a portion, gorgeous in its effect. The plate of Lombard Chimnies gives one-and-twenty varied designs. The article Façade shows two arcaded buildings. There is likewise a Flemish brick front in the Gothic style. The Metal Work gives some picturesque knockers.

Attached to this part is some description of the buildings represented in the two parts of the volume for this year.

Buildings and Monuments, Modern and Mediæval. Edited by George Godwin, F.R.S. London: 1850. Part VII.

The church of the Immaculate Conception, by Mr. Scoles, exhibits some very rich tracery; the church of La Villette, at Paris, is interesting, as showing how parish churches are treated there; the Custom-house, Rouen, is a novel piece of street architecture. There are likewise other subjects, and as some details are given, the number will be a very acceptable addition to the library.

Sections of the London Strata. By Robert W. Mylne, C.E. F.G.S., F.S.A., M. I.B.A. London: James Wyld. 1850.

Mr. Mylne's work, no doubt, will meet with its full share of favour, it being particularly useful to all who are engaged or interested in the sanitary progress of the metropolis. There are five sections; the first alone has the strata delineated in detail, with the necessary geological references: the remaining four sections are only in outline; but as the author intends to complete them from materials already collected, the horizontal and vertical scales are in the proportion of 18 to 1. The engravings also show the site and depth of all the principal wells which have been sunk in and about London. We hope this work will induce other engineers and architects to observe and describe the structure of the country around them, for at present our knowledge of the crust of the earth is very inaccurate and limited.

Hydraulic Tables. By Nathaniel Beardmore, M. Inst. C.E. London: Waterlow. 1850.

Hydraulic engineering is so extensively practised as to require a considerable number of works for its practitioners; and Mr. Beardmore has rendered a very essential service by the publication of this hand-book, which in a very close compass gives the materials requisite for the calculation of water and mill-power, water supply, drainage, and the navigation of rivers, tables of the rainfall in England, and some subsidiary information. From Mr. Beardmore's experience and high-standing, we should have been prepared for a more extensive work, and more copious information.

The Civil Engineer's and Surveyor's Companion, and Assistant in Setting out Slopes, &c. By Edward Ryde, Surveyor. London: Published by the Author, 1850.

These pages constitute a set of tables for setting out slopes, curves, cuttings, and embankments, and as they are intended to

save labour to professional men, will be welcomed. There is one part of Mr. Ryde's labours which might have been better applied: he has given his relative proportions in chains horizontally, and feet vertically; instead of this it would have been better had he taken the foot measure instead of the link, both horizontally and vertically. It has been found practically better to use the 100 feet chain instead of the 100 links in setting out railway works.

Architectural Sketches, Italy. By T. C. TINKLER, Architect.

The number now before us gives several details of the Villa Madama, near Rome, lately destroyed by the French: they chiefly exemplify a loggia. The Villa Borghese, though sketched on a small scale, is very picturesquely shown. Bits from the Campagna are sketches of several country buildings, showing the general effect and arrangements, and are of some interest.

Drawing from Objects. By HANNAH BOLTON. London: Groombridge. 1850.

This is a work founded on the system of drawing from common geometrical forms, which is now so prevalent in this country, and in which the writer has had much experience, having taught, in the last six years, nearly two thousand pupils, many of them teachers of national and infant schools. For a work of this kind it is well carried out, and in a liberal spirit; but we adhere to the opinion that it is better to begin with natural objects, instead of the stiff forms taken from conventional geometry.

The Telotype—a Printing Electric Telegraph. By FRANCIS GALTON, Esq., M.A. London: Weale. 1850.

This pamphlet describes at length Mr. Galton's invention, the object of which is to print messages in the ordinary alphabetical characters, and for which many ingenious contrivances are introduced. As the plan requires several engravings for its explanation, we are unable to compass it in a short description.

WATER SUPPLY FOR LIVERPOOL.

REPORT OF ROBERT STEPHENSON, C.E., *on the Supply of Water to the Town of Liverpool.*

(*Continued from page* 193.)

I now proceed to answer the first question in the Minute of January, 14, viz.—

"*Whether a supply sufficient, as regards quantity and quality, for the present and prospective wants of the town and neighbourhood, including domestic, trading, and manufacturing purposes, and shipping, and for public purposes—viz., watering and cleansing streets, flushing sewers, extinguishing fires, and supplying public baths and wash-houses, can be obtained by additional boring or tunnels, or otherwise, at the present stations—viz., those purchased from the Companies respectively, and from the Green Lane Works, now vested in the Corporation, and the cost of obtaining such sufficient supply?*"

It is, I believe, admitted that the population at Liverpool to be supplied with water is about 400,000, and that an efficient supply for large towns is not less than twenty gallons per individual daily; thus the total quantity required at the present time is 8,000,000 gallons a-day. In the Report made by the Health of Towns Commissioners, it is stated that the increase of inhabitants in Liverpool was, for the ten years between 1831 and 1841, 39.6 per cent.; we shall probably, therefore, not err much in supposing the population to be supplied in 1861 will be 557,500, and the necessary quantity of water consequently augmented to 11,150,000 gallons a-day. But, in the first place, I shall consider the various schemes which have come before me in reference to a population requiring 8,000,000 gallons only.

My experiments to determine the yield of the wells are detailed in several tables of the Appendix, No. 1 of which gives those made to ascertain the effect of one stroke of the pump at each station; and, as the correctness of the final results depended on the accuracy of this element, much time and labour were given to the subject. Implicit reliance may therefore be placed on the experiments, which were made by discharging the water from the pump alternately into two tanks of known capacity (one being emptied while the other was being filled), and repeating this operation for a considerable length of time. The total quantity of water thus measured, divided by the number of strokes, of course gives the content of one stroke. The pumps, buckets, and clacks were tried in various conditions and under different pressures of water, and the utmost care was taken to secure the same relative conditions throughout the duration of the experiments, so as to obtain both the delivery of each stroke and the yield of the well.

At the Windsor station, where the engine was single-acting and the length of stroke variable, an apparatus was applied for the purpose of registering the exact distance passed through by the pump-rod; and, by reading the index of this instrument, and taking the number of strokes as given by the counter, the average length of stroke for any period was ascertained; and thus the total quantity of water discharged accurately determined. It was intended to have used this instrument at Green Lane also, but as it was required at Windsor to measure the increased yield during the progress of the boring, this could not be done. The yield of the Green Lane well was in consequence ascertained by proving the delivery of the pump, when working at a known length of stroke, by means of the tanks, and afterwards confining the length of stroke, throughout the subsequent experiments, as nearly as practicable to the same standard. The yield of the well at Bevington Bush, and the delivery of the pumps at the Bootle Station, were determined by pumping into a reservoir of known capacity and regular shape, at Kirkdale.

Table No. 2 shows the yield of each of the wells at various levels; Table No. 2 A the maximum yield; and Table No. 2 B the yield at the working levels of the last quarter of 1849, as proved both by the Dip-books and by my series of experiments.

These tables show that the maximum yield of all the wells in the possession of the Corporation amounts to 5,170,486, the minimum yield to 3,320,990, and the yield at the ordinary working level to 4,216,784 gallons per 24 hours. This, as recorded in the Dip-book, shows at corresponding levels a delivery of 3,834,758 gallons, which is as close an approximation as could be looked for. Mr. Hocking reported to Messrs. Simpson and Newlands that the yield of the wells was 4,220,969 gallons in April, 1849, but as the weekly produce is divided by six instead of seven, this amount ought to be 3,677,972 gallons. From all these results it may be inferred that the existing wells are yielding about 4,000,000 gallons a-day.

After the full explanation, in the preceding pages of this report, respecting the action of wells on each other, and the mode by which the water is transmitted throughout the body of the sandstone, it will at once be perceived that the expectation of much augmenting the supply of the present wells, either by sinking, boring, or tunnelling, cannot be entertained.

I am satisfied that any increase occasioned by deepening these wells will be temporary, and only take place to the same extent as the private supply of water is diminished. This would necessarily lead to the deepening of the private wells, which has already been done to a considerable degree; and when finished, would leave all parties in the same relative positions, except that they would have the same quantity of water, or a very little more to lift a greater height; and it cannot be doubted that a large proportion of any increase would be derived from the River Mersey, as all the wells are now sunk to or below the level of low water, and many yield brackish water.

Another theory of Mr. Gage may be here specially referred to. It seems to be that the water flows into wells from beneath, and is made to do so entirely from statical pressure, acting at a great distance and elevation; but the ascertained levels of the water in the sandstone and wells are to me totally irreconcileable with this notion, for if the pressure upwards which he supposes to exist were really operative, the level of the water in the sandstone ought to be uniform or very nearly so, which is certainly not the case. In the first exposition of his views he stated that the water flows through large fissures with comparative freedom, and supported this by pointing out the specific chemical differences in the water from adjoining wells; but this is no proof of his correctness, as the sandstone itself is far from being of uniform composition, and may give rise to much variety in the constituents held in solution, while the character of the surface in the vicinity of the well may also influence the quality of the water in the sandstone. Could the probability that the supply of water is derived from the Welsh or Yorkshire hills in any way be imagined, the friction alone, which is an ascertainable quantity under known circumstances, would prevent the possibility of the rapid flow of the large

quantity of which Mr. Gage predicts would be obtained by means of bore-holes.

The question of expense points to the propriety of diminishing rather than increasing the supply from the existing wells; indeed, the advantage of abandoning some of them has already been pointed out by Mr. Newlands, Mr. Kennedy, and others, and a Table is introduced into the Appendix, showing the costliness of the water at present obtained from all except Windsor and Green Lane, by which it would appear that their abandonment, and the establishment in their place of two new ones, similar to, or somewhat more extensive than Green Lane, would produce a saving of 3,992*l.* per annum on the working expenses, or enough to justify an expenditure on the new and more economical establishments of 80,000*l.*, in addition to the value of the land and works; whereas, the two stations would not cost more than about 56,000*l.*

Messrs. Simpson and Newlands' Scheme.

The second question contained in the Minute is,

"*Whether a sufficient addition to the present supply can be obtained in the locality or neighbourhood of Liverpool, as recommended by Messrs. Simpson and Newlands, or by borings, or by any other course, and the cost of obtaining and distributing the same.*"

This question comprehends the plan now before parliament, which may be called the Newsham House Scheme; Messrs. Simpson and Newlands' Scheme, as described in their printed report of April 23rd, 1849; and Mr. Simpson's Kirkby or Clock House Bridge Scheme.

The Newsham House Scheme consists in making a well 192 feet deep, at a distance of about 590 yards from Green Lane Station, with 8 furlongs 248 feet of tunnel; a new engine and well of 150 feet deep, with 600 feet of tunnel at Bootle, and 1 furlong and 240 feet of tunnel from the bottom of the Windsor well.

After the free communication which has been proved to exist between the Green Lane well and those surrounding it, situated at much greater distances from each other than that proposed at the Newsham House Estate, I am at a loss to understand how the latter can largely increase the supply from the district. The distance between the proposed site and Green Lane is only 590 yards, and the end of the tunnel 1,300 yards, while that between the Windsor and Edge Hill wells is 960 yards; and in their case we find that the aggregate quantity of water raised is not much increased by adding to the wells, as before making the bore-hole at Windsor the railway wells at Edge Hill only gave a daily increase from that district of about 380,000 gallons. The proposed extension of the works towards Newsham House is little more than a repetition of these circumstances; the extent of tunnel is certainly greater, and will, in proportion, extend the contributing area, but not so efficiently as to justify the expectation of a very much more advantageous result, or one commensurate with the cost of the works.

The enquiry as to what distance wells should be placed from each other, in order to yield a maximum result, is here suggested. It is in evidence, that when the pumping at Green Lane was forced, wells not far from Windsor were affected, and others at a greater distance laid dry. These, perhaps, may be regarded as extreme cases; but I cannot think that two public wells, from which large quantities of water have to be drawn, should be established nearer to each other than Windsor and Green Lane, a distance of $1\frac{3}{4}$ or 2 miles. At this distance these wells appear to be capable of yielding 1,000,000 gallons a-day each.

The proposed tunnels at Windsor would operate as a reservoir, in which respect they would, no doubt, be useful for storage, but that they would sensibly increase the permanent yield of the well is very doubtful. The proposed additions to Bootle, the only station which supplies nearly 1,000,000 gallons per diem at about forty feet above low-water mark, will increase, for a time, the yield of that establishment; but in considering the question of its improvement, it must be remembered that it it is the most expensive on account of the royalty agreed to be paid annually to Lord Derby.

As I believe the results contemplated from this project to be but problematical, I cannot refrain from recommending a pause before entering upon the expenditure which the execution of the proposed works will necessarily involve.

Messrs. Simpson and Newlands' project, as described in their printed report of 23rd April, 1849, appears to be an extension of the Newsham House Scheme, involving a larger expense without, I fear, accomplishing a corresponding benefit.

The present Green Lane Works cost about 19,000*l.* for buildings, machinery, and wells, but exclusive of mains. The extension now proposed by driving a tunnel three miles long from the existing well (after it has been deepened), to the north, towards Melling, cannot, I believe, sufficiently increase the contributing area so as to add to the present yield 6,000,000 gallons a-day, as assumed by its projectors. No plans or details having been submitted to me, the only information I possess is that to be derived from the printed document and the general estimate, which do not enable a minute examination of the various items of cost to be made; but I do not doubt that the amount named, 192,556*l.*, is sufficient for the execution of the works.

Mr. Simpson, in the Kirkby or Clock House Bridge Scheme, proposes to obtain from wells situated near each other, and tunnels uniting them, 4,000,000 gallons a-day, and an equal quantity from two branches of the river Alt. The area of water-shed of this district would yield the quantity; but the proposed reservoir of about 30 acres in extent, and 15 feet in depth, would be quite inadequate as respects storage, to ensure so large an uniform daily supply; and I am satisfied, from a personal examination, that it would be a task of great difficulty to construct one sufficient for the purpose in this place.

The wells in this situation may probably be as productive as those elsewhere, although Mr. Binney and Mr. Rowlandson expressed some doubt of it, and the district is low, and the rock probably fully charged with water; but I can perceive no circumstance to justify us in supposing that the transmission of the water to this point can take place more easily than it has been found to do elsewhere, or data upon which to calculate safely on so large a supply as that suggested from wells situated at one point.

The engine-power requisite for the purpose of pumping 8,000,000 gallons a-day to Liverpool, is considerably under-rated; but, were the proposed works in other respects adequate to the necessary supply, I believe the aggregate estimate would be sufficient.

These observations on the Kirkby project are equally applicable to any proposal for deriving a supply from the Childwall Valley; indeed, every objection to the former applies with even greater force to the latter district. There is about the same area of water-shed, but greater difficulties as regards storage—to such a degree, that this alone is enough to put it entirely out of the question.

The proposed plans of the Marquis of Salisbury have also been examined; they consist of about three miles of tunnel, with their shafts, all comprised within an area of about three-quarters of a square mile, which is quite insufficient for the supply of the town; and even if considered merely as an auxiliary, the gain from it will be unequal to its probable cost.

(To be continued.)

OBITUARY.

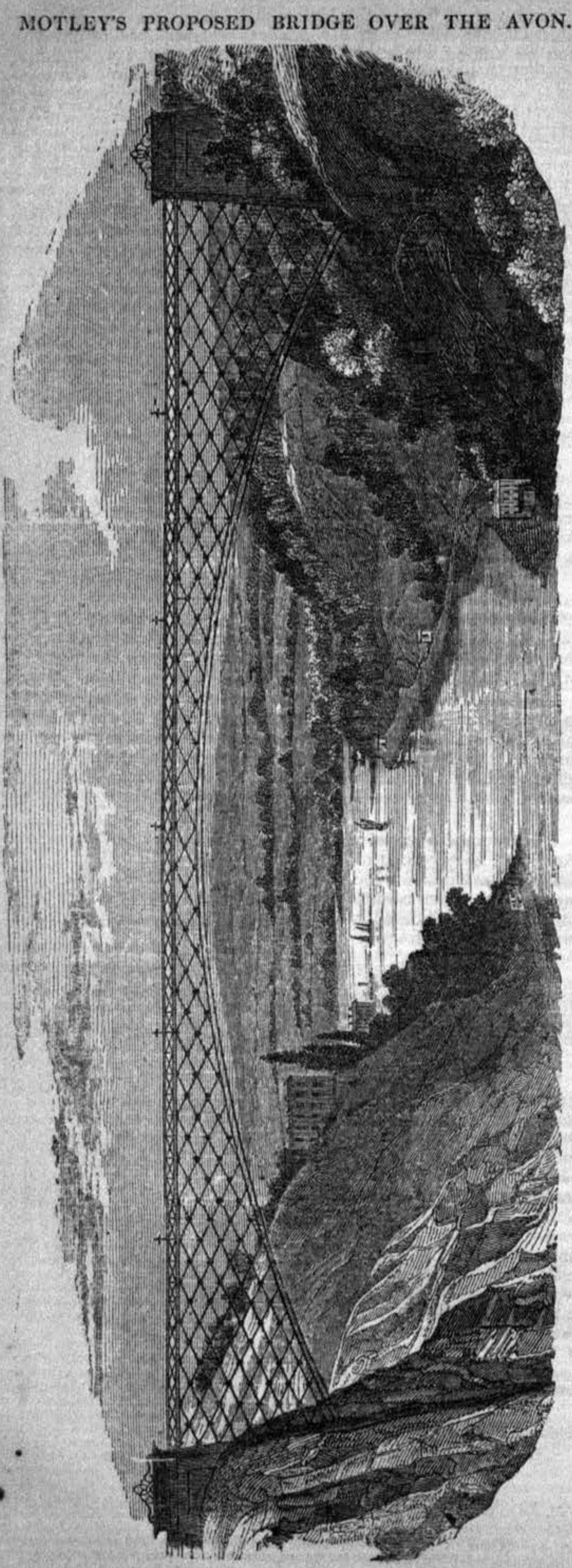
Sir—I regret exceedingly to have to inform you of the death of a remarkably rising young architect, an occasional contributor to your *Journal*, Mr. John Swindell, of Kilburn Priory. His treatise on "Well Sinking," and other similar occasional minor performances, have at times been the subject of your favourable review. I have, however, well-founded reason to believe, that those small productions I have alluded to were merely the results of leisure hours; and that, had he not, by incessant work, worn out his frame, he would have ultimately benefited his profession in an eminent degree, by investigations of a far more important and more original character than those I have alluded to. I shall, I hope, find myself excused in your eyes, and those of your readers, in thus assisting to rescue from oblivion the name of one who, had he not come to an untimely grave, would have required no assistance of the sort.

I am, &c.
B. Pemberton,
Professor of Civil Engineering, R.A.C.

Royal Agricultural College,
June 11, 1850.

M. Luigi Zandomeneghi.—The *Venice Gazette* lately announced the death of this celebrated sculptor, aged 71. He had been for some years engaged in the sculpture of a magnificent monument to the memory of Titian. This important work, though far advanced, has been left unfinished by his death.

MOTLEY'S PROPOSED BRIDGE OVER THE AVON.



THE above engraving exhibits a design for a bridge of 600 feet span, which Mr. Motley proposes to construct over the river Avon, at St. Vincent's Rocks, Clifton: he states that it can be built without any centring. At a distance of 80 to 100 feet from the verge of the rock he proposes to drive a number of iron piles, united sufficiently strong to bear a strain of several thousand tons, to which powerful tension-bars would be fastened, on the river end of which cranes of sufficient strength would be attached, and, by the aid of a moveable platform, the first portion of the bridge would be hung on the principle of a suspended bracket; this would continue to be enlarged in length and depth, and as the work would commence on both sides simultaneously, the bridge would meet in the centre, and its perfect rigidity be effected. The cost of the iron work of such a bridge, Mr. Motley states, for a span of 600 feet, and to sustain a uniform load of 1000 tons, *with perfect safety*, would not exceed 30,000*l*. A model of the bridge may be seen at the office of the *Mining Journal*, in Fleet-street.

LAIRD'S GALVANISED IRON SECTIONAL BOATS.

Mr. Macgregor Laird has communicated to the *Nautical Magazine* the annexed illustration of iron-built galleys and boats he is now constructing. Mr. Laird states that this construction is a simple contrivance to enable merchant vessels to carry without inconvenience, boats that, in case of need, would save the lives of crew and passengers;—men-of-war, to carry double the number of boats in the space now occupied, discovery vessels to carry large tenders;—travellers to carry boats in the space of a moderately sized trunk;—and merchants trading to the open ports of the Pacific and Indian Oceans to send out lighters and small craft, at the usual rate of freight.

The sketches are the plans, elevations, and sections of two descriptions of boat, built on the sectional principle. The larger one (figs. 1 to 4) is a galley, 70 feet long and 12 feet beam, to be propelled by negroes with paddles.* This boat is for the use of her Majesty's Consul at Fernando Po, to enable him, without reference to calms or baffling winds, to proceed when required to any point within his district, which embraces the Bights of Benin, Biafra and Panasia, a line of coast of 1000 miles in extent, having the beautiful island of Fernando Po in the centre.

"To those of your readers who know Mr. Beecroft, and have been upon the coast, I need not remark upon the advantages, the facility of taking the boat to pieces, and reuniting her in a few hours without the assistance of mechanical or skilled labour, will give that distinguished traveller in his future geographical discoveries. And from my own experience I can truly say that if I had again to ascend any African river, I would prefer three or four of these galleys, each manned and propelled by fifty Kroomen, to the best equipped steamers that ever left England.

Commercially, steamers can only pay in civilised countries. Their excessive cost at first, and the constant outlay afterwards, has ruined all African trading expeditions into the interior; while

* The following letter is from Commander Bevis, R.N., to Mr. Laird :—

"SIR—With reference to your letter of the 8th ult., with its enclosure from Mr. Macgregor Laird, relative to a sectional boat built of galvanised iron, said to be ready for survey on the 16th ult. (but is not yet in a finished state), and desiring me to take to my assistance some competent officer at Liverpool, who has been on the coast of Africa to inspect this boat, and report upon her efficiency, I beg to report for the information of my Lords Commissioners of the Admiralty, that I have on several occasions inspected the boat, and once in the presence of Mr. Beecroft, the Consul at Fernando Po, there being no African officer in this neighbourhood, and find her dimensions and efficiency as follows, viz.:—

Length	68 feet	Builder's Measurement ..	45 tons
Beam	12 "	Total weight of ironwork ..	$4\frac{1}{2}$ "
Depth amidships	4 "	Do. with woodwork, masts, sails, all complete	8 "
Depth forward and aft ..	6 "		

Thickness of plates 3-16 and $\frac{1}{8}$-inch; displacement at 1 foot water line 7·65 tons; ditto 2 feet 20 89 tons.

"There are eight sectional pieces, the heaviest of which is 16 cwt., joined together by angle-iron joints, lined with vulcanised indian rubber, the whole being secured together by screw-bolts and nuts, so that her own crew of forty or fifty men, can carry her over any neck of land, and set her up again.

"Her light draft of water is estimated at 1 foot with her crew, with provisions, water, &c., for the same, at 2 feet. She is to pull thirty-eight oars, double-banked, fitted with three schooner sails, jib and square-sail, having for night protection iron stanchions covered with thin felt; she is also to be fitted with air-tight galvanised tubes as a life-boat.

"From her light draft of water, and general lightness, she is particularly well adapted to take the bars on the coast of Africa, where there is a short breaking sea, and *for proceeding up the rivers, or to go in chase of slavers, as from her construction she must pull and sail very fast.*

"It is proposed by Mr. Beecroft, that this boat should be fitted with a light brass six-pounder forwards; and with her crew trained to small arms, she would be fit to go in chase of any slavers in a calm, therefore submit that this class of boat, with increased or diminished dimensions would be of great service to the African squadron as tenders.

"I am, &c.,

Liverpool, 7th March, 1850. "THOMAS BEVIS, Commander."

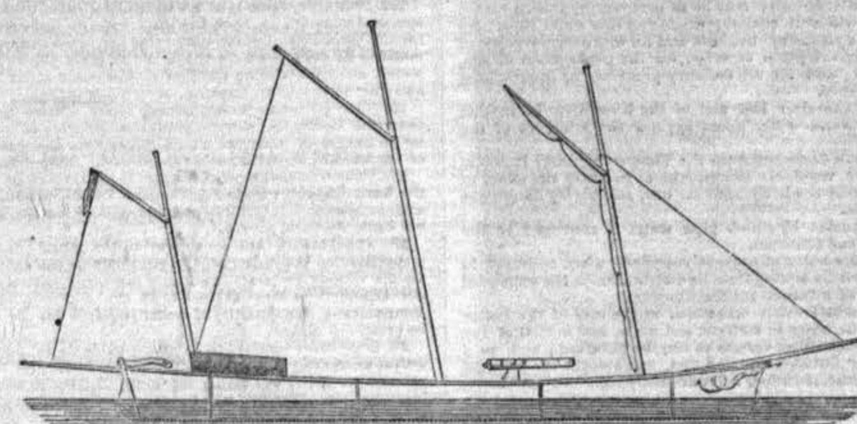
galleys of this description would have done all that has been done at a twentieth of the cost, and perhaps 'ere this, have opened a regular and steady trade with the tribes in the interior.

The second boat is building for an emigrant ship (figs. 5 to 8). She is in four sections, and can be used as an ordinary boat of 26 feet long (figs. 7 and 10), as a barge 38 feet, or a galley of 50 feet (fig. 5), at which size she would carry in safety 150 people.

Fire is the great danger to be apprehended on board emigrant vessels. In an hour after a fire was discovered these boats could be joined and towing astern, and the awful scenes that took place on board the *Ocean Monarch* and *Caleb Grimshaw* avoided.

All naval officers who have served on the coast of Africa, and the Indian Seas, know the advantages of having large and fast boats. On this sectional plan, a boat 60 feet long can be stowed in a length of 25 feet on the booms, and be put together in a few minutes by her crew, when her services are required to chase in calms or baffling winds, or to land troops; or, fitted as a tender, she could be sent to cruise with a month's provisions and water on board; a simple and cheap way of doubling the efficiency of a blockading squadron. Droghers, lighters, and small craft of all sorts and sizes, can be sent out to all parts of the world, at the lowest rate of freight, and put together with the greatest facility and accuracy, without the aid of mechanics or skilled labourers.

I may add, that I propose making all boats for passenger-vessels life-boats, by using Light's prepared rushes, which are much superior to any system of air-chambers, and securing them from oxidation by galvanising the plates, which also saves the expense of painting."



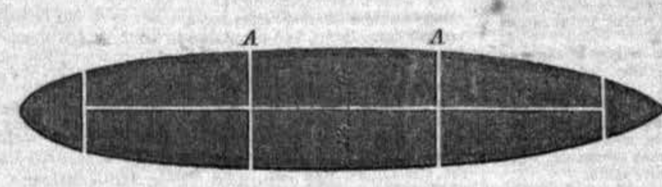
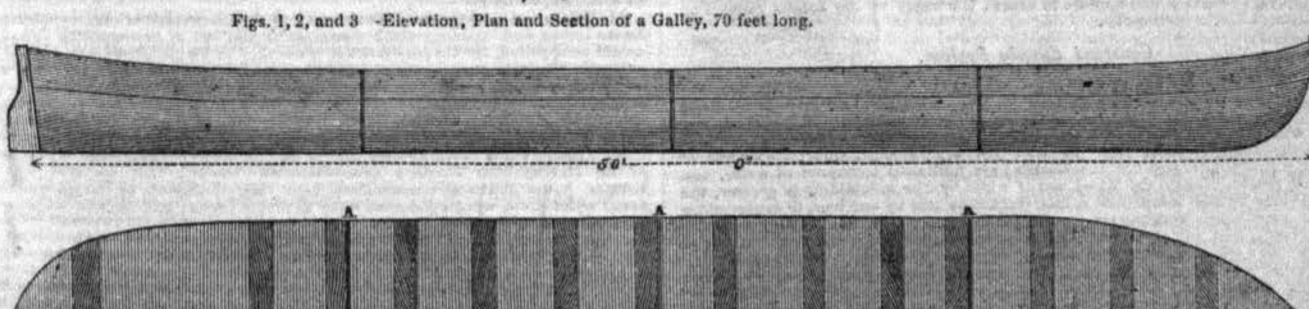


Fig. 4. —Cross Section at A.

Figs. 1, 2, and 3 -Elevation, Plan and Section of a Galley, 70 feet long.



Figs. 5 and 6.—Elevation and Half-plan of Sectional Boats of Galvanized Iron, for an Emigrant Ship of 600 tons, carrying 300 people. Scale ⅛ of an inch to a foot.

Fig. 7.—Plan of Section at A.

Fig. 8.—Cross Section at A, showing the method of joining the Sections. Scale ½ of an inch to a foot.

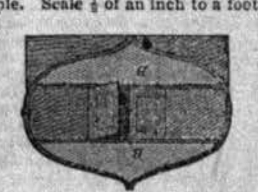


Fig. 11.—B, Water-tight Bulkheads, Sections at end of Midship Sections, showing the Sections as a Deck-house.

Fig. 9.—Elevation of Fore and Aft Sections, as a Cutter 26 feet long, and 8 feet beam, for ordinary ship's use.

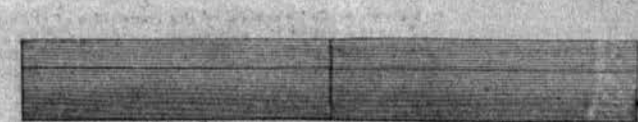


Fig. 10.—Midship Sections, stowed on Booms, to be used as store-rooms, or water-tanks, on the voyage, containing upwards of 3000 gallons.

SUPPLY OF WATER TO THE METROPOLIS.

Report *by the General Board of Health on the Supply of Water to the Metropolis.*

We have given at length the recommendations of the Commissioners, as to the plan they propose for adoption; but the report itself requires considerable discussion, which we must, however, defer, our space being otherwise taken up.

Quality of the Water of the River Thames.

1. That for domestic use it is inferior to the average quality of waters supplied to towns.

2. That its inferiority as a supply for domestic use arises chiefly from an excess of hardness.

3. That even when taken above the reach of pollution from the sewers of the metropolis it contains an excess, varying with the season, of animal and vegetable matter.

4. That although this latter cause of inferiority may be in part removed or corrected by filtration, the excess of hardness will still remain, rendering this water especially unfit for the following uses—namely, for cleansing the skin and for ordinary purposes of washing, by occasioning an excessive consumption of soap; for the preparation of tea, by occasioning waste to the like extent; and for all culinary processes by diminishing their efficiency and increasing their expense.

5. That the quality of the water in the river Lea and of the New River is, in this respect, no better than that of the Thames water taken beyond the influence of the sewage of the metropolis.

6. That the water taken by the Lambeth Company from the Thames opposite Hungerford-market is charged with animal and vegetable impurities, apparently the effect of the discharge of sewer water, which render it wholly unfit for use, and highly dangerous to the health of the persons who drink it.

7. That of the seven principal companies by which pipe water is conveyed to the metropolis, four deliver it without previous filtration.

8. That the defects in the quality of the water at present supplied, when collected in its least objectionable condition, and the evils arising from its distribution in the unfiltered state, are all aggravated by the practice of intermittent distribution.

9. That the practice of intermittent distribution occasions, in the case of the better description of houses, the retention of the water in cisterns and butts, and in that of the poorest classes, in tubs, pitchers, and such other vessels as can be obtained; and, as a consequence of such retention, the water imbibes soot and dirt, and absorbs the polluted air of the town, and of the offensively close, crowded, and unhealthy localities and rooms in which the poor reside.

10. That from the inferiority of the water at its source as at present collected, and from the additional pollution and deterioration occasioned by the mode of its distribution, a large proportion of the population is rendered averse to the daily use of water as a beverage, and is inclined and almost forced to the use of fermented liquors and ardent spirits to an extent greatly beyond the consumption of such drinks where purer water is more accessible.

11. That the annual cost of the construction and maintenance in repair of cisterns and their supports and connected apparatus in the houses of the middle and wealthier classes often exceeds the annual water-rate.

12. The cost of the pipe water supply and the additional expense and inconvenience resulting from the present mode of its distribution cause the population in some suburban districts to resort for water to open ditches, and in other crowded localities to shallow springs or wells; sources which are subject to increasing pollution from cesspools, from badly constructed house drains and sewers, and from overcrowded graveyards.

13. That the localisation and intensity of cholera in such districts as those alluded to were promoted in a most marked manner by the use of water containing decomposing animal and vegetable matter derived from sewers, drains, and other impure sources.

14. That the districts most severely visited by epidemic cholera, as well as those afflicted by ordinary epidemic diseases, are low-lying districts where, from the defective state of the drainage, there is an excess of damp and of putrid decomposition; and that such excess of damp is aggravated by the waste of water attendant on the intermittent mode of supply; a waste which appears to exceed the whole of the annual rainfall on the inhabited area of the metropolis.

Constant Supply System.

Many practical difficulties having been urged against the substitution of the constant for the intermittent system of water supply in the metropolis, we have particularly examined into the working of the constant system of towns where it is established, and in some of which it has been in operation for 15 and 20 years, and we find—

15. That the waste of water is so far less, instead of greater, under the system of constant supply, that although the inhabitants have unlimited command of water, and use what they please, though the actual use of water by the inhabitants is greater, the quantity delivered by the companies is less, frequently less by one-half, in consequence of there being less waste from the more perfect delivery.

16. That the water, under the system of constant supply, is delivered purer and fresher, of a lower temperature in summer, and that it is less subject to frost in winter.

17. That the inconvenience apprehended from the interruption of supply during repairs and alterations, are never experienced, the work being executed under such simple precautions that no complaint has ever been known to have been made on this account.

18. That the interruptions of supply, which are so constantly experienced on the intermittent system from the waste in the lower districts, from the neglect of turncocks, from limitation of quantity, from inadequate or leaky butts and cisterns, or from deranged ballcocks, are scarcely ever known on the constant system.

19. That the system of constant supply admits of great economy in pipes, as they may, under that system, for the most part, be considerably smaller, and, not being subject to the violent hydraulic jerks of the intermittent system, are less liable to burst.

20. That the pipes for the house service may not only be considerably smaller and cheaper, but that the cisterns and apparatus connected therewith, which, in the smaller class of houses, now cost more than the whole public portion of the works, may be entirely dispensed with.

Quantity requisite.

In respect to the quantity of water actually supplied, and to the quantity needed for the domestic use of the metropolitan population, and for other purposes, we have to report—

That in consequence of statements made by several of the companies of the quantities of water which they pumped for the use of the metropolis, quantities which appeared to be inconsistent with the known habits of the population and the apparent amount of water consumed for domestic purposes, we deemed it desirable to cause the consumption of water in different districts, by different classes of the population, to be gauged from the cisterns and butts, and also the run through house-drains and sewers on days when there was no rainfall.

From these observations it appears—

21. That, whereas it was returned, in 1832, that the average quantity of water delivered to their respective customers by the several companies was 220 gallons per house or dwelling—and more recently, as returned to us, was stated to be 164 gallons per house or dwelling—that is, 44,000,000 gallons per diem for the whole of the metropolis—making allowances for a considerable and injurious waste of water by permeation through badly constructed channels, the results of the gaugings of the run of water through drains and sewers, on days when there is no rainfall, do not appear materially to differ from the later statements of the several companies as to the quantity of water which is actually pumped into their several districts; while from the gaugings of the quantities of water consumed from cisterns and butts during the intervals of the intermittent delivery, and from the capacity of the storage receptacles themselves, it appears that the average daily consumption does not exceed five gallons per head on the population, and that, with all allowances for the quantities used for manufactures, steam-engines, and other purposes, the gross quantity consumed does not exceed one-half of the quantity delivered.

22. That this waste is a consequence of the present intermittent mode of supply, and does not take place to any such extent where the constant system of supply has been substituted, and probably may be prevented altogether where the house service pipes are properly provided and arranged under a system of combined works.

23. That this waste, as now ascertained by official investigation, appears to have gone on without any knowledge of its great amount on the part of the companies, although it involves a double expense of pumping, and exceeds, as above-stated, the whole of the annual rainfall on the covered area of the metropolis.

24. That this waste is of no equivalent benefit for the cleansing of house drains and sewers, inasmuch as, from the inaptitude of these works, owing to their bad construction, for the discharge of water containing matter in suspension, accumulations of decomposing matters do take place in them to the great injury of the public health; accumulations which, notwithstanding the flow of the waste water through them, require to be cleared away by hand labour, flushing, or by other means.

25. That the waste water, having sewer matter mixed up with it, permeates through the brick drains and sewers, saturates the sites of houses with polluted water, and keeps up an excess of moisture which, rising into the porous and absorbent walls and plaster of the houses, contributes to render them damp even in the driest weather.

26. That this excess of moisture is aggravated by the extremely defective drainage in the low-lying and worst-conditioned districts, where, as has been already stated, epidemic disease is almost invariably present, and where the recent visitation of epidemic cholera has been the most severe.

27. That, taking into consideration the actual domestic consumption of water by the population of the metropolis, regarding also the extent of the increased supplies needed for the various purposes of sanitary improvement not hitherto contemplated by companies, nor included in new schemes, all the engineering estimates put forward by private companies of the quantity of water required for the service of the population, appear to be greatly in excess.

28. That there appears to be no probable demand for a general average consumption of water exceeding the present rate for houses of the higher class—namely, about 75 gallons per house per diem; or, in all, 22,000,000 of gallons per diem, inclusive of the increased supply which will be necessary on the abolition of cesspools; and that, estimating the additional requirements for baths, for street-cleansing, for large consumers, for fires, and for other purposes, the whole quantity of water needed under an improved system of distribution does not exceed 40,000,000 of gallons per diem.

29. That it appears that the resolutions of parochial meetings and the statements of the promoters of new companies, alleging a deficiency in the total amount of water already introduced, and proposing to bring in additional supplies, have beeen made in ignorance of the actual present domestic consumption of the population, and of what is really needed, according to the best information, for the execution of practical measures of sanitary improvement.

30. That the several schemes which propose to bring in more water in addition to the quantity now wasted, and to make such additions mainly from the same sources which supply the water now generally consumed, without reference to improvements in the system of domestic distribution, and without combination with improved drainage-works for the removal of the waste water, would aggravate the existing sanitary evils, and increase the excessive charges already incurred for the defective works constructed in ignorance.

Flushing System.

Having particularly examined the statements as to the increased quantities of water required for the flushing of drains and sewers, and the working of an improved system of drainage, we find—

31. That upon a system of drainage such as that at present in use, consisting of brick house-drains and sewers, which cause accumulations of decomposing deposits, there would be required, for the intermittent removal of those accumulations by flushing, considerable additions to the present quantities of pipe water pumped in for the supply of the metropolis, but that any system of house or main drainage which occasions the accumulation of decomposing refuse, and renders necessary the continuance of the practice of intermittent flushing, is in itself highly injurious to the public health, and ought to be prevented.

32. That recent trial works have placed beyond doubt the soundness of the conclusion of the Metropolitan Sanitary Commissioners—namely, that systematically adjusted tubular house drains and sewers are kept clear of deposit by the force of the soil or sewer water alone, when conducted away at proper levels; and that no addition of water is required for this purpose.

Sewerage of the Metropolis.

With reference to those extensive districts of the metropolis the levels of which are below high-water mark, where the sewer water is at present penned up until it can be discharged at low water, and where putrefying deposit is accumulated in the sewers in consequence of the flow being arrested during high water, it appears—

33. That it will require no addition of water, and certainly no increased expense in pumping, to cause such a continuous flow of the waste water as will prevent deposit; and that this prevention of deposit is the true object to be aimed at, and not the supply of additional quantities of water to remove, by flushing, deposit which ought not to have been allowed to accumulate.

34. That besides the great injury to the public health from the ponding up of sewer water and the consequent conversion of large expansive sewers and reservoirs into extended cesspools; and, besides the waste of water and the expense of pumping it into the district for the removal of accumulations, the intermittent system of draining the districts below high-water mark by gravitation, without the aid of pumping for their relief, must necessitate the continued pollution of the Thames, and obstruct or delay the application of the refuse as manure.

35. That, except in extreme cases of absolute deficiency, the pumping in of additional supplies of water, before properly constructed house drains are laid down for its removal, would, by increasing damp, still further deteriorate the sanitary condition of the population, and occasion still greater dilapidations and injury to tenements.

36. That the separation of works of pipewater supply from those for the removal of waste water occasions delay in the execution of works of primary importance for sanitary improvements, as well as increased expense.

37. That it appears that while the expense of sewers and drains is reduced by an improved tubular system of drainage, the expense of earth-work, of digging, and making good, is one-half of the total expense, and that, therefore, the separate laying down of watermains and drainage mains must frequently cause this last portion of the expense to be materially increased.

38. That on these grounds, and on the principles already recognised, the only way of securing systematic works with economy and efficiency, as well as with the least delay,

will be to consolidate under one and the same public management, the whole works for the supply of water, and for the drainage of the metropolis.

39. That it is essential to the economy and efficiency of all such works that the whole distributory apparatus, small as well as large, service pipes, and house drains, together with watermains, public drains, and sewers, should be laid down under one system, and kept in action under one supervision.

40. That it appears from the examination of improved works which have been in operation for a sufficient length of time to test their efficiency, and from detailed estimates made by different competent engineering officers upon house-to-house examinations of the worse conditioned districts, that combined works, comprising a water pipe for the service of each house, a sink, a drain, a waste pipe, and a soil-pan or watercloset apparatus, may be laid down and maintained in action at a cost not exceeding, on the average, 1½d. per week, or less than half the average expense of cleansing the cesspool for any single tenement.

41. That the general survey being now sufficiently advanced, such works may be executed for separate districts, without waiting for the completion of any general measure or plan of main sewers.

Provision for Supply.

Having considered the evidence in relation to the qualities of the water requisite for the supply of the metropolis, we find:—

42. That, in addition to the properties of clearness and freedom from animal and vegetable matter which is apt to pass into decomposition and to prove injurious to health, one of the most essential properties of water is softness, or freedom from lime and other substances productive of what is termed hardness.

43. That, having made careful and extensive inquiries, with the aid of the department of the Ordnance geological survey, as to the most suitable sources of supply, having had those districts which appeared to be the most eligible specially examined by our engineering inspectors, with other aid, we find, upon their unanimous testimony, that from a tract of upwards of 150 square miles of gathering ground* there is derivable a supply nearly double the present actual domestic consumption, of a quality varying from one-tenth to one-third the hardness of Thames water, and of a purity equalling the general average of the improved soft-water supplies of the districts which have yet been brought under examination.

44. That water obtained from silicious sands, such as those which cover the tract above described, is proved to be of a quality only equalled in excellence by the water derived from mountain granite rocks, or slate rocks, or other surfaces of the primitive formations.

45. That upon the estimates which have been obtained, this water may be brought to the metropolis and delivered pure and filtered into each house on the system of constant supply at high pressure, and, at the same time, on the plan of combined works, the waste water may be removed by a proper system of drainage, at a rate not exceeding an average of *3d.* or *4d* per week per house, or from 30 to 50 per cent. less than the present charges for defective water supply alone.

46. That the saving of soap, from the use of soft water in the operation of washing (the expense of washing linen and other clothes being estimated at an average of 1s. per head per week to be nearly 5,000,000*l*. per annum on the population of the metropolis) would be probably equivalent to the whole of the money expended at present in the water supply.

47. That the saving in tea from the use of soft water may be estimated at about one-third of the tea consumed in the metropolis.

48. That other culinary operations would be much facilitated by the use of soft water.

49. That soft water is peculiarly suitable for baths, as well as for washing.

50. That soft water would prevent those incrustations and deposits in boilers and pipes which render hard water unsuitable for manufacturing purposes.

Recommendations of the Commission.

We therefore advise the rejection of all the schemes promoted by water companies, or by parochial vestries and associations, which adopt, as sources of supply, the Thames and its tributaries of the same degree of hardness, wells, and springs from the chalk or other formations which impart the quality of hardness.

And further, whilst we believe that Thames water taken up beyond the influence of the metropolitan drainage, and filtered, may be used without injury to the public health, and may be employed temporarily until other sources can be laid under contribution, we advise that Thames water, and other water of like quality as to hardness, be as early as practicable abandoned.

In respect to the existing companies which have no property in any of the sources of water supply, but whose capital is invested in engines and distributory apparatus, we recommend that their plants should be purchased, but we are not prepared to recommend any pre-appointed terms of purchase; and we find—

51. That, if the management of the water supply be consolidated, five if not six out of the seven principal pumping establishments may be discontinued, and an expenditure of from 80,000*l*. to 100,000*l*. per annum saved by consolidating the management of these works and connecting them with combined works of drainage and sewerage, and that further reductions may be made in the expenses of these latter establishments.

Having considered, as required under the Metropolitan Sanitary Commission, the means of supplying water to extinguish fires, and having examined the practical experience of improved works in relations thereto in other towns, we find—

52. That the inadequacy of the supplies of water under the intermittent system occasions great danger to life and property, but that by arrangements which are practicable under a system of constant supply at high pressure, the whole force of the water in the mains may be brought to bear at any point for extinguishing fire in from one to five minutes, or in about one-fourth the time that it takes the best appointed fire-engines now to gain the spot and be in action after the alarm of fire has been given.

53. That, judging from the experience of various places where improved arrangements have been put in practice, it appears that by the general adoption of these arrangements more than two-thirds of the fires which now occur in the metropolis may be extinguished before any extensive damage takes place.

54. That the insurance risks on life and property may be diminished in a yet greater proportion.

55. That the crime of incendiarism may be checked, and that these consequences alone, were there no other advantages to be obtained, would render it worth while to make the change from the intermittent to the constant system.

56. That these advantages may be best given by the same means by which a more perfect and cheaper surface cleansing of courts, alleys, foot-pavements, and carriage-ways than that by hand may be effected—namely, by jets of water distributed under high pressure.

Proposed Plan for the Metropolis.

Having considered the most eligible administrative provisions for the execution of the required works, we concur in the principles recommended by the commission of inquiry as to the best means of improving the health of towns, and confirmed by Parliament in the Public Health Act, viz.:—

57. That the works of water supply, and those for drainage, or the removal of soil or waste water, should be carried into effect by one and the same administrative body.

58. But that the magnitude of the metropolis, the diversity of its local jurisdictions, and its position as the seat of government, and the occasional residence of persons from all parts of the empire, the large minorities requiring protection, and the unaccustomed magnitude of the requisite outlay, render distinct and special provisions necessary for it, and that the amendments required may be most speedily, safely, and economically executed by special or by provisional arrangements.

59. That a general survey under the direction of the engineers of the Board of Ordnance, and other surveys, trial works, and preparations essential to the safe and economical executions of combined works of water supply having been completed, under the direction of the consolidated Metropolitan Sewers Commission, such combined works may now be executed and maintained at a lower rate of charge per house than has heretofore been incurred for any of their various branches executed separately.

60. That the initiation and executive direction of such works by members, however highly qualified, giving casual attendance at meetings held weekly or fortnightly, causes grievous delay, and that in cases which measures for preventing disease or arresting its progress require the utmost promptitude.

61. That, considering the great loss and suffering incurred by the delay in carrying the required works into execution, it will be expedient to confide their further preparation and superintendence to a few competent and responsible officers, of whom a certain portion should be paid, giving their whole time and attention to the subject. That the whole of these works be carried into execution by contract upon open tenders, not merely for the construction of the works, but for maintaining them in good action and repair for terms of years.

62. That the means provided by the Public Health Act for giving publicity to plans and estimates of intended works, with opportunities of suggestion and appeal, be extended to the works proposed for the sanitary improvement of the metropolis.

63. That the proper execution of the works will be best guaranteed, the responsibility of the persons charged with their execution best insured, and the interest of the poorest classes of the population (the inhabitants of the most depressed districts, who, though they pay no direct local rates, pay heavy rents), will be best guarded in the special case of the metropolis, at all events provisionally, by the direct control of Parliament; the importance of the proposed measures to the health, convenience, and comfort of large masses of the population, the magnitude of the required constructions, the amount of outlay, and the dangers of failure and waste as well as delay being, from experience of separate works already constructed, such as to render it necessary that the highest order of continued and undivided attention and responsibility should be secured for the execution of such works as this Report recommends."

* The district from which the proposed supply is to be taken is Bagshot Heath.

ROYAL SCOTTISH SOCIETY OF ARTS.

April 22.—Patrick Wilson, Esq., in the Chair.

The following communications were made:—

1. *On a New Method of inducing an upward Current in the Upcast Shaft of Coal-Mines, to promote Ventilation.* By Mr. J. Seton Ritchie, Edinburgh.—The author adverted to the vast numbers, as workers, and dependants on them, interested in the adoption of means by which freedom from danger in coal-mines may be attained; then, mentioning the theories by which mine-explosions are accounted for, he noticed the numerous methods which have been proposed for maintaining mines in a state of safety, and particularly the method in general use of inducing an upward current of the air of the mine by means of a fire at the lower part of the upcast shaft, that, as the provision of a separate shaft for the removal of the air of the mine is prevented by the great additional expense, even though mechanical appliances may appear highly calculated to maintain a powerful and steady current, difficulty exists in their application, as interfering with the free working of the produce of the mine carried on by the upcast shaft, which is further increased in making provision for continual reliance on them, as spare appliances would require to be provided. The author stated that the method now proposed is free from this obstacle. The current is induced by means of pipes heated by water circulating in them, fixed round the circumference of the shaft in such manner within the line of it, as shall shield them from injury, leaving sufficient exposure of them to communicate their heat to the air in the shaft; the furnaces for heating the circulating water being at the nearest convenient distance, at a considerably lower level than the orifice of the shaft, as on the depth at which they are placed will depend the perpendicular extent of the upper part of the shaft around which the pipes may be placed. Certainty of action could, with ordinary caution, be relied on, as, even if one of the circulations ceased, from any cause, to act, the others would during that time continue in action. A similar application might also be made at the lower orifice of the shaft, and even extended in some measure to the workings; or the fires now in use at the foot of the shaft might be retained, and the application alone made at the upper part in aid, to promote greater certainty and steadiness in the current. It was submitted that a similar application might be made of steam as of water. It was pointed out that the maintaining of the upward current in the shaft is but one section of the keeping the mine in a state of safety—that, though this will never be effected without a steady and powerful extracting current in the shaft, the latter will be of little avail, unless accompanied by carefully-laid-out air-courses throughout the mine itself, properly modified as the working advances, attention on the part of those appointed to open and close the doors which it becomes necessary to erect in them to direct the currents, and attention that that the building off of exhausted sections of the mine be as frequently as possible accomplished, that they may not become next to permanent reservoirs of noxious gases, ready to lend their aid to a general explosion.

2. *Description of a Water-Meter.* By Mr. F. A. Bucknall, New Swindon, Wilts.—The author stated that the object of this meter is the measurement of the supply of water to private dwellings, breweries, &c. It consists chiefly of a fan-shaped bucket-wheel, revolving within a cylindrical case, and kept water-tight by means of packing, made of India-rubber, leather, or other elastic substance, supply and delivery pipes, and wheel and pinion gear, which is connected with an index plate. The revolving action of the meter is maintained by the gravity of the wheel being constantly greater on the one side than on the other, owing to the continuous running off of the

water from the opposite side to that at which the water is supplied. The meter is only in action during the time the water is running off.

3. *Description of a New Liquor-Pump, calculated to prevent the Liquor from being contaminated with Verdigris and Oil in the interior of the Pump-Barrel; also applicable to the Pumping of Acids.* By Mr. HAY DALL, Glasgow.—The author stated the following as the disadvantages of the present system of pumping liquors—1st, That each liquor requites a separate pump. 2nd, That the liquor, in passing through the barrel of the pump, corrodes its interior, especially in the case of fermented liquors, thus producing constant decay in the barrel and valves, and also an accumulation of verdigris in brass pump-barrels, which, together with the oil or tallow used to lubricate the piston, is constantly mixing with and contaminating the liquor. The inventor stated that he had his attention frequently directed to the disgusting state of the interior of corroded pump-barrels which had been sent in for repair—that, generally, every crevice and corner of the piston and barrel where it could collect, was clogged with a poisonous and nauseous compound of stale beer and oily verdigris, ready to mix in greater or less quantity with the next liquor that would pass through it. That in the new method one pump can be made to supply any number of liquors, while the liquor never gets into contact with the pump-barrel. The pump is used solely as an air-pump to withdraw the air from the interior of a series of glass or earthenware vessels, properly arranged, and made to communicate with the liquor casks by tubes immersed in the liquor. When the cocks are properly arranged, and the pump is worked, the liquor rises and fills the vessel, never having passed through the pump barrel at all, and when the vessel is full, the pumping is stopt, and the liquor is run off into the vessels from which it is to be drunk, by a common cock.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM MAY 23, TO JUNE 20, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

William Radley, chemical engineer, and Frederick Meyer, oil merchant, both of Lambeth, Surrey, for improvements in treating fatty oleaginous resinous, bituminous, and cerous bodies, in the manufacture and application of them, and of their components and subsidiary products, together with the apparatus to be employed therein to new and other useful purposes.—May 25.

Edwin Pettitt, of Birmingham, civil engineer, for improvements in the manufacture of glass, in the method of forming or shaping and ornamenting vessels and articles of glass, and in the construction of furnaces and annealing kilns.—May 25,

John Hickman, of Walsall, Stafford, clerk, for improvements in the manufacture of cylindrical and other tubes.—May 25.

Alfred Vincent Newton, of Chancery-lane, mechanical draughtsman, for improvements in couplings for carriages, and in the attachment of wheels to axles. (A communication.)—May 28.

James Ashworth, of Rochdale, Lancaster, manufacturer, and Thomas Mitchell, of the same place, manager, for certain improvements in machinery or apparatus for preparing, spinning, and weaving cotton, wool, and other fibrous materials.—May 29.

Jonathan Harlow, of Birmingham, for improvements in the manufacture of bedsteads and other articles for sitting or reclining on.—May 30.

Edwyn John Jeffery Dixon, of the Royal Slate Quarries, Bryntrafood, near Bangor, North Wales, for improvements in the manufacture of sinks and other articles of slate or stone.—May 30.

Thomas Page, of Middle Scotland-yard, Middlesex, civil engineer, for improvements in the construction and means of cleansing sewers.—June 1.

Ezra Jenks Coates, of Bread-street, Cheapside, London, merchant, for improvements in the manufacture of bolts, spikes, and nails.—June 1.

Moses Poole, of the Patent Bill Office, London, gentleman, for improvements in machinery for punching metals, and in the construction of springs for carriages and other uses.—June 1.

Arthur Elliott, machine maker, of Manchester, and Henry Heys, of the same place, book-keeper, for certain improvements in machinery for manufacturing woven fabrics.—June 1.

Guillaume Ferdinand de Douhet, of Clermont Ferrand, France, gentleman, for improvements in the disoxygenation of certain bodies, and the application, separately or simultaneously, of the products therefrom to various useful purposes.—June 1.

Frank Clarke Hills and George Hills, of Deptford, Kent, manufacturing chemists, for certain improvements in manufacturing and refining sugar.—June 1.

Samuel Brown, of Lambeth, Surrey, engineer, for improvements in engines for measuring and registering the flow of fluids and substances in a fluid state, which improvements are also applicable to steam and other motive engines —June 1.

John Tucker, of the Royal Dockyard, Woolwich, Kent, shipwright, for improvements in steam boilers, and in gearing, cleansing, and propelling vessels. (A communication.) —June 1.

George Hayward Ford, of St. Martin's-le-Grand, Middlesex, gentleman, for improvements in obtaining power.—June 3.

Paul d'Angely, of Paris, France, gentleman, for certain improvements in the construction of privies and urinals, and in apparatus and machinery for cleansing privies, cesspools, and other places, and in deodorising the matter extracted therefrom, and rendering it available for agricultural purposes.—June 4.

David Napier and James Murdock Napier, of the York-road, Lambeth, Surrey, engineers, for their invention of improvements in apparatus for separating fluid from other matters.—June 4.

Theodore Cartali, of Manchester, merchant, for certain improvements in the treatment or preparation of yarns, or threads, for weaving. (A communication.)—June 4.

William Watson, the younger, of Chapel Allerton, York, manufacturing chemist, for improvements in the preparation and manufacture of various materials to be used in the processes of dyeing, printing, and colouring.—June 4.

John Sykes and Adam Ogden, both of Dock street, Huddersfield, York, wool cleaners and machine makers, for certain improvements in machinery for cleaning wool, cotton, and similar fibrous substances from burrs, motes, and other extraneous matter.—June 4.

Edmund Sharpe, of Lancaster, master of arts, for certain improvements in railway carriages.—June 5.

William Edward Newton, of Chancery-lane, civil engineer, for improvements applicable to boots, shoes, and other coverings for, or appliances to the feet.—(A communication.)—July 6.

George Jackson, of Belfast, Ireland, flax-spinner, for improvements in heckling machinery.—June 6.

John McNicoll, of Liverpool, engineer, for improvements in machinery for raising and conveying weights.—June 6.

William Robertson, of Gateside-hill, Neilstone, Renfrew, Scotland, machine maker, for improvements in certain machinery used for spinning and doubling cotton, and other fibrous substances.—June 6.

James Alexander Hamilton Bell, New York, America, merchant, for improvements in dressing bran, pollard, and sharps. (A communication.)—June 6.

A grant unto William George Bicknell, of Essex-street, Strand, and James Reginald Torin Graham, of the Grove, Clapham Common, of an extension for the term of six years of letters patent granted by his late Majesty King William IV., to Miles Berry, of Chancery-lane, patent agent, for certain improvements in machinery or apparatus for cleaning, purifying, and drying, wheat or other grain or seeds.—June 7

William Newton, of Chancery-lane, civil engineer, for certain improvements in the manufacture of cords, ropes, bands, strong cloths, quilting, sacks, and cushions, and in elastic material for stuffing the latter, in which manufacture caoutchouc forms an essential ingredient, and in the application of parts of these improvements to the manufacture of pads, stoppers, tubes, boxes, baskets, coverings, wrappers, and other like articles of utility. (A communication).—June 8.

James Colman, of Stoke Mills, Stoke, near Norwich, Norfolk, mustard and starch manufacturer, for improvements in the manufacture of starch.—June 8.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, London, for certain improvements in oscillating engines put in motion by steam and gas resulting from combustion. (A communication).—June 8.

Charles Warwick, of Cheapside, warehouseman, for improvements in apparatus for taking up the work of certain descriptions of knitting machinery. (A communication)—June 8.

Peter Armand Lecomte de Fontainemoreau, of South-street, Finsbury, for certain improvements in the manufacture of sulphate of soda, muriatic and nitric acids. (A communication).—June 11.

William Edward Newton, of Chancery-lane, civil engineer, for improvements in machinery for carding cotton, wool, or other fibrous materials, and an apparatus for preparing or setting the cards of carding engines. (A communication)—June 11.

William Jackson, of Kingston-upon-Hull, soap maker, for improvements in the manufacture of soap, and in the preparation of materials for this purpose.—June 11.

William Edward Newton, of Chancery-lane, civil engineer, for improvements in rotary engines. (A communication).—June 11.

Robert Waddell, of Liverpool, Lancaster, engineer, for certain improvements in steam engines. (A communication)—June 11.

Alexander Parkes, of Pembrey, Carmarthenshire, experimental chemist, for improvements in smelting and treating certain metals, and in the construction and manufacture of furnaces and the materials to be used for the same, such furnaces and materials being applicable to the treatment of metals and metallic compounds, and to various other useful purposes of a like nature.—June 11.

William Pole, of Great George-street, Westminster, engineer, and David Thomson, of Belgrave-road, Pimlico, engineer, for improvements in steam-engines.—June 11.

John Henry Vries, Esq., of Norfolk-street, Strand, Middlesex, for improvements in working engines by atmospheric air.—June 11.

James Palmer Budd, of the Ystalyfera Iron Works, Swansea, merchant, for improvements in the manufacture of coke.—June 11.

John Dearman Dunnicliff, of Hyson Green, Nottingham, lace manufacturer, and John Woodhouse Bagley, of Radford, in the said county, lace maker, for certain improvements in lace and other weaving.—June 11.

Samuel Ellis, of Salford, engineer, for improvements in machinery or apparatus applicable to all kinds of carriages used on railways.—June 11.

Frederick Albert Gatty, of Accrington, Lancaster, manufacturing chemist, for a certain process or certain processes for obtaining a carbonate of soda and carbonate of potash.—June 11.

William Cox, of the firm of William Cox and Co., of Manchester, cigar merchant, for certain improvements in machinery or apparatus for manufacturing aerated waters, or other such liquids.—June 11.

John Sidebottom, of Broadbottom, Chester, manufacturer, for improvements in looms for weaving.—June 11.

William Mac Lardy, of Manchester, machinist, for certain improvements in machinery or apparatus for preparing and finishing, and doubling cotton and other fibrous materials. —June 12.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the production of gases to be used for lighting, heating, and motive power purposes. (A communication).—June 12.

Gustavus Palmer Harding, of Bartlett's-buildings, London, artificial florist, for improvements in the manufacture of buttons and other fastenings.—June 12.

Thomas Deakin, of Balsall Heath, Worcester, Esq., for certain improvements in machinery and apparatus to be used in rolling metals and in the manufacture of metal tubes —June 12.

John Stopporton, of the Isle of Man, engineer, for certain improvements in propelling vessels.—June 12.

William Edward Newton. of Chancery-lane, civil engineer, for certain improvements in the construction of railways. (A communication.)—June 12.

George Allen Everitt, of the firm of Allen, Everitt, and Son, of the Kingston Metal Works, Birmingham, metal and tube manufacturers, and George Glydon, of Birmingham aforesaid, engineer and foreman to the said Allen, Everitt, and Son, for certain improvements in the manufacture of metal tubes for locomotive, marine, and other boilers.—June 12.

John Manly, jun., of Birmingham, manufacturer, for certain improvements in the manufacture of nails.—June 12.

Charles Lamport, of Wortrington, Cumberland, ship-builder, for certain improvements in machinery or apparatus for lifting and moving weights, working chains, and pumping, which improvements are more especially adapted to ship use —June 19.

Charles Greenway, of Green-street, Grosvenor-square, Middlesex, for improvements in ships' and other pumps, in anchors, and in propelling vessels.—June 19.

Benjamin Cheverton, of Camden-street, Camden-town, Middlesex, artist, for methods of imitating ivory and bone.—June 19.

Charles Hanson, of Stepney, Middlesex, engineer, for certain improvements in steam-engine, steam-boilers, and safety valves, and in apparatus and machinery for propelling vessels.—June 19

Isaac Hartas, of Wretton Hall, York, farmer, for improvements in machinery for obtaining motive power. (A communication.)—June 19.

Robert Heath, of Manchester, iron merchant, and Richard Hendley Thomas, of Woolstanton, Stafford, engineer, for certain improvements in the manufacture of iron.—June 19.

Ethan Baldwin, of Philadelphia, Pennsylvania, United States of America, for a new and useful method of generating and applying steam in propelling vessels, locomotives, and stationary machinery.—June 19.

Robert Weare, of Angel-court, Throgmorton-street, clock and watch manufacturer, for certain improvements in the means and apparatus for extinguishing fire, and in galvanic batteries.—June 19.

George Robarts, of Tavistock, Devon, gentleman, for certain improvements in clogs and pattens.—June 19.

Gaspard Malo, of Dunkirk, France, shipowner, for certain improvements in propelling vessels.—June 20.

CORN MAGAZINE AT NOVOGEORGIEVSK.

(*With an Engraving, Plate IX.*)

The chief trade in Russian Poland is in the supply of wheat, as is well known to those accustomed to corn-law discussion, and it is an incident of that trade to be subject to very great fluctuations. For the whole of the exports Dantzic is the port, receiving the produce by the Vistula and its affluents, the Bug and the Narew, and the harvests from Cracow to Thorn, and being the only place of shipment. The trade at Dantzic is, to a great extent, carried on with England, and by English houses, or with English means; and in cheap years the Polish corn is bought up, and was formerly kept in the granaries of Dantzic until a favourable state of the market and duty here allowed of its shipment; but now that the Customs restrictions are removed, cargoes are bought in Poland, and warehoused here. However beneficial it is to the English merchant to buy in the cheapest market and sell in the dearest, yet, to the Polish landowner or tax-payer it is a matter of great moment, and therefore of no less to the Russian government, that he should not be forced, by his necessities, to sell at the lowest price to the English agents. The Emperor of Russia, taking this state of affairs into consideration, issued an edict, decreeing, that on various points of the Vistula magazines shall be established, in which, during low prices of corn, every one shall have leave to warehouse grain, and by means of the Polish Bank, obtain advances, so as to be in a position to hold out until a better market can be obtained.

In pursuance of this edict, a point was chosen at the junction of the navigable Narew with the Vistula, close to the fortress of New Georgievsk, formerly called Modlin, and 22 miles from Warsaw. The Emperor directed that a magazine should be established there, with the double purpose of being a corn warehouse to receive the produce of the Bug, the Narew, and the Vistula, on the way to Dantzic, and of being a granary for the fortress of New Georgievsk, which is one of the largest garrisons in Europe. The execution of this project was put under the direction of what is called the Polish Bank, an institution somewhat after the Birmingham model, which issues paper money, and forms trading establishments, among which is an ironfoundry and factory. The building was likewise to serve the purposes of the Bank, by giving it a place of deposit for the crops on which advances were made.

The place chosen is on a tongue of land between the rivers Narew on the right, and Vistula on the left; and which being subject to the inundations of the two streams, is insulated during much of the year. On the right bank of the Narew is the town of Modlin and citadel of New Georgievsk. Under its guns, in the middle of the waters, is the warehouse. On the left bank of the Vistula, commanded by the citadel and the warehouse, is a large outwork, to keep up the communications.

The directions of the Emperor were, that not only a warehouse should be built, but that its lower story should be bomb-proof, in casemates, and pierced with embrasures, to carry guns both on the side of the Vistula and the Narew. The architect charged with the direction of the work was Mr. Jacob Gay, though of what nation he is we are unaware.

The situation, as we have intimated, is very low, with a slimy soil, and occasionally flooded by both rivers. It, therefore, became necessary to lay the foundations on firm pilework, the more particularly as they were to carry enclosure walls of unusual thickness, and a building of five stories in height. Besides, it was necessary to provide an embankment on the Narew side, on which the Warehouse could be placed above the greatest rise of the water, which, in 1813, was 23 feet. In order to provide against any further extraordinary flood, and the upheaving of great blocks and flakes of ice accumulating in the neighbouring islands of the Vistula, it was resolved that the lowest floor should be laid two feet above the water-mark of 1813.

The first works began in 1835, and the driving of the piles and laying of the foundations was entrusted to Heer J. Singhels, an engineer from Holland, then in the service of the Polish Bank. He began with a fascine-dam in the bed of the Narew, 20 feet from the line of the foundation. The piles driven under the front walls and piers were 2800 in number, each 30 feet long and 10 inches square, shod with iron. These works were carried out in the winter of 1838 and summer of 1837, at the time of the lowest water, which varies very much in the Vistula, for though at some times of the year boats drawing more than two feet water cannot navigate it, yet it will suddenly rise 20 feet.

In order to carry on the works as free from water as possible, a 12-horse power steam-engine was set up, and kept pumping day and night, until the foundations were got six feet above the level of the water. In the month of March, 1837, the height of the foundations had reached 10 feet above the water level, when an unexpected flood, which rose 15 feet, burst into the works, and suspended them. On the waters falling, a fortnight after, it was found that the walls and arches of the foundations were in nowise injured, but that the chief mischief was in carrying off some of the materials prepared. In the autumn of 1837 the embankment and foundations were fully brought to an end. The whole embankment on the Narew side is faced with strong sandstone, from some very rich quarries lying on the Vistula, about 150 miles from Warsaw. This stone has been likewise much used in other parts of the construction. The smallest stone used for facing the embankment or retaining wall, is 8 feet long, 2 feet broad, and 1½ feet thick. The thickness of the walls behind the sandstone and the inner foundation are of mountain granite, with strong layers of hydraulic lime, and all hollows and interstices of the stone are filled in with broken granite and hydraulic lime.

The inner foundation is carried on piers of granite and arches of brick set with hydraulic lime, and each pier is bonded with iron thrice in its height. All the foundations are filled-in with earth to the height of the embankment, as cellar room is not wanted, and the whole space before the warehouse on the Vistula side is raised by filling to the same height as the quay wall on the Narew, and secured where it lies against the stream of the Vistula by a dam 200 rods long, constructed on the most approved plan of those in Holland. On the top of the basement wall, which batters, is a balcony of cast-iron, and on the wall are strong hooks for making fast barges and boats.

The cost of the basement wall and embankment was 23,000*l.* (155,000 silver roubles), and in consequence of numberless unforeseen difficulties, exceeded the estimate by 9000*l.* In April, 1838, Mr. Gay began the building of the magazine, and having the materials ready prepared, and the labour of 250 Russian masons, the vaulting-in of the bomb-proof casemates was effected in the July following.

In the same month the building was inspected by the Emperor, and he gave permission for several deviations, which Mr. Gay's experience had pointed out. In November, 1838, the whole building was roofed-in, and most part of it covered with zinc against the approaching winter, so that in the ensuing year nothing was expected to be done but the completion of the roofing and the laying of the floors. In the course of 1838 they used up 11,000,000 bricks, 60,000 cubic feet of sandstone, and above 3000 logs, 40 feet long and 10 inches by 12.

The preparation of these materials was attended with considerable difficulty, as the neighbouring fortress was likewise in progress, and for which 50,000,000 bricks were yearly required; besides which, the site of the building was confined by the waters, and all the materials had to be raised from the river to a height of 60 feet by slow and toilsome labour. Single blocks of sandstone for the vaulting of the gateways, for corner stones, and for the cornice on which the fourth and fifth floors rest, and which measured 30 or 40 cubic feet, were dragged up from the barges in the Narew by the physical strength of the Russian masons.

The progress of the works was slower in 1839, but on the 13th of July the building was near its completion, when the roofers, at a time when a gale was blowing, by some want of care, let redhot coals fall on the woodwork of the roof, which catching, fire spread throughout the building, and in four hours all that was consumable was in ruins. On subsequent examination it was found that none of the walls of brickwork had lost any of their strength, although the beams which kept them together had been burnt through. The bomb-proofs received no injury. The sandstone on the Vistula façade was the most affected. The whole cornice on which the overhanging upper floors rest was so much injured as to require many repairs. It was small consolation to the architect in such vexation to find that the construction of his walls was good under an unexpected proof, but he had at least the comfort of being entrusted with the re-construction.

In the re-construction, iron columns were in many cases introduced to carry the girders, and Mr. Gay found it necessary to remove many of the blocks in the cornice which had been injured by the fire. For this purpose a scaffolding was put up, the injured stones taken out, and new ones put in. At last, these and the other works were carried out and completed; and the magazine being filled with wheat, and the guns on the lower story being fired, the building was found to stand all tests, and it is said to have since remained in a good condition. In the summer of 1840

the completion was announced, and the Emperor was shown over the building. The whole cost, from the foundation upwards, setting aside damage from the fire, was 70,000*l.* (465,000 silver roubles) and the excess over the estimate was 4500*l.* (30,600 silver roubles), caused by heavier wages to labourers, and rise in the price of materials.

In the middle of the building is a doorway and passage, which is likewise bomb-proof, and which reaches through two stories, as well as the ground-floor. In this gangway is a moveable granary, the invention of M. Valery of Paris, by which a thousand bushels of wheat are cleaned at once. From this doorway, as well as from both others on the Narew side, iron stairs reach to the river, for lading and unlading from the boats. In the windows and on the floors strong cranes are placed. On the Vistula side is only one doorway in the middle of the building, as this façade constitutes a battery to command the Vistula. The length of the building is about 600 feet (600 Polish feet), and the breadth about 100 feet. The height in the wings on the Narew side, with the basement wall, is 90 feet, and on the Vistula side 23 feet lower. After the fire the roof was covered with iron sheeting. The windows in the three stories, and in the lower floor, are made without parapets, and so that fresh air for the ventilation of the corn can be readily admitted. The upper windows, it should be observed, are each divided by a floor, so as to make five stories besides the casemates. The cornice on which the fourth and fifth stories rests, and which is in the Castellated style, projects with the upper wall about one foot and a half. It is decorated with masks of various designs, in sandstone, which serve the purpose of ventilators for the lower part of the fourth story. The whole of the floor of the first story is laid with asphalte, the use of which in Poland was introduced by Stanislas Wysocki, engineer of the Vienna and Warsaw Railway. All the castings were supplied from the works of the Polish Bank in Warsaw.

The building has not the usual appearance of a granary, but being partly of a military character, a peculiar style was adopted, which is not inappropriate, and in which Mr. Gay has chiefly followed the example of the castellated mansions of Florence. It thus acquires a bold and monumental character, worthy of its massive construction, and may justly be ranked among the finest buildings in Russia, of which so many distinguish the present government, and as being without a parallel in Europe.

The seat of the magazine is one of the strongest points of the system of fortification, and it rises above the two rivers and the waters of the inundation, with its images glittering in the streams on a fine day with a most picturesque effect. On the opposite shore of the Narew is the citadel, and some long lines of barracks, on rising ground about 80 feet high; and the two banks are united by a temporary wooden bridge, which is hereafter to be replaced by a suspension bridge. The width of the Vistula is about 1700 feet (and which can likewise be bridged), and that of the Narew 900 feet. The town and fortress communicate, by paved roads on each side of the Vistula, with Warsaw; and when the water permits, two steamboats run.

For this information, and for the engravings, we are indebted to the *Bauzeitung*; and we only regret that we are not in possession of more practical details.

LECTURES ON THE HISTORY OF ARCHITECTURE;

By Samuel Clegg, Jun., M.I.C.E., F.G.S.

Delivered at the College for General Practical Science, Putney, Surrey.

(PRESIDENT, HIS GRACE THE DUKE OF BUCCLEUCH, K.G.)

Lecture VIII.—*The Parthenon—Erechtheion—Theatres, &c. Domestic Architecture of the Greeks.*

The Parthenon was commenced about 448 B.C., on the site of the old temple called the Hecatompedon, which was destroyed 32 years before by the Persians under Mardonius. It was situated on the highest ground in the Acropolis, where it stood a masterpiece of art. Dr. Clarke says: "To a person who has seen the ruins of Rome, the first suggestion made by a sight of the buildings in the Acropolis is that of the infinite superiority of the Athenian architecture: it possesses the greatness and majesty of the Egyptian or of the ancient Etruscan style, with all the elegant proportions, the rich ornaments, and the discriminating taste of the most splendid era of the arts." "In all that relates to harmony, elegance, execution, beauty, and proportion," he continues, "the Parthenon stands a *chef d'œuvre*; every portion of the sculpture by which it is so highly decorated has all the delicacy of a cameo." This temple of the Doric order, octastyle and peripteral, may be considered as a perfect example of the principles of Greek architecture, the harmony of proportion and the severe uniformity of its masses blending and contrasting with the endless diversity of line and curve formed by the sculpture with which it is adorned. The charge of its erection was committed to the architects, Ictinus and Callicrates, under the general superintendence of Phidias. The beasts of burden employed in carrying up the materials were thenceforward exempted from any less sacred work; and one that had voluntarily headed the train was kept at pasture during the rest of its life at the public expense. The whole of this magnificent edifice was constructed of Pentelic marble; no cement was used, but the margins of the blocks were polished, so as to fit with greater exactitude—a style of masonry that, from its beauty, was called by the Greeks "*harmonia.*" The blocks composing the columns (including the capitals) were twelve in number. They were united by a cylindrical wooden pin, inserted into a plug about 5 inches square and 3 inches deep, let into a corresponding mortice in the blocks. The dimensions are 227 feet by 101 on the upper step. It consisted, besides the Pronaos and Posticus, of two apartments, the Cella and the Opisthodomos. The former or eastern chamber is 62½ feet in breadth, and 98 ft. 6 in. in length; the western chamber is 44 feet in length. The total height of the temple, from the stylobate to the summit of the pediment, is 65 feet. The exterior columns (eight in each portico, and seventeen along the flanks, including those at the angles) are 6 ft. 2 in. lower diameter, and 35 feet in height. The ambulatory is 9 feet in width. Vitruvius advises that, in order to correct the delusion caused to the eye by the apparent deviation of a long horizontal line, the stylobate should be slightly raised towards the centre, and that the architrave should descend with a corresponding curve. He also directs that the axes of the columns at the angles and along the flanks should be inclined, the faces next the walls of the cella being perpendicular to the stylobate; so that the whole diminution of the shaft should be given to the exterior. Both these rules have been observed in the erection of the Parthenon, a fact discovered by Mr. Pennethorne. The upper step in the eastern front forms a curve, rising 3 inches in the centre; the architrave also curves, the curve being increased in the cornice. The columns of the peristyle incline inwards 1½ inch from the perpendicular. The ceiling of the Opisthodomos was supported by four columns of about 4 feet diameter. This apartment was the treasury of Attica and her allies. The Prytanes kept the key of the Opisthodomos, as well as that of the Acropolis; one of these officers was chosen by lot, and was entrusted with the keys for one single day and night, during which time he was called the Epistates, or president; when his term of duty had expired, the charge passed to another of the same body. The treasures belonging to the temple, consisting for the most part of votive offerings, were of great value. Pausanias mentions the dedication of golden shields; and Alexander the Great, after the battle of the Granicus, sent 300 suits of Persian armour as offerings to Minerva in the Parthenon. In the interior of the Cella were sixteen columns, of 3 ft. 6 in. diameter; the order employed is uncertain, the only vestige that has been found amongst the ruins being one mutilated Corinthian capital. Mr. Lucas, by a careful measurement of the marks left by the bases, and a comparison of the information attainable on the subject, has concluded that the lower range of interior columns must have been Ionic, and the upper Corinthian; and has thus restored it in his model in the British Museum. The interior apartments and the vestibules are raised two steps from the stylobate; six columns *in antis* of 5½ feet diameter led into the vestibule at either end of the building. The central part of the Cella, as in all the temples to the superior divinities, was hypæthral. Here stood the great statue of Minerva, wrought in gold and ivory by the hand of Phidias; it was 39 feet in height, exclusive of the pedestal, and carried a golden spear 40 feet in length. When Phidias returned from Elis, the enemies of his patron Pericles, accused him of peculation in regard to the gold employed on the statue. Fortunately, by the advice of Pericles, Phidias had formed the gold plates so that they could be taken off and weighed; and by this means the foul calumny was refuted; but his accusers, determined not to be again foiled, brought a charge against him of impiety, alleging that he had introduced portraits of Pericles and himself on the shield of the goddess. He was upon this thrown into prison, where he died, as some assert, by poison, just as the last great work of Pericles, the Propylea, was completed (432 B.C.) As Mr. Lucas observes, "The embellishments

of the Parthenon are an epitome of the history of the people, alike in their religion, their patriotism, their deeds of valour, and the religious ceremonials of their existence." The sculpture of the two pediments represents on the one the birth of Minerva, or her presentation to the gods of Olympus; on the other the contest between Minerva and Neptune for dominion in Athens. The subjects on the metopæ were taken from the most celebrated conquests of the Athenians; and on the frieze surrounding the exterior of the Cella, the Panathenaic procession was represented. Nor were the embellishments confined to sculpture alone. Under that unclouded sun, Nature exceeded in brilliance and vivacity everything that man could produce, and so allowed the use of polychrome ornament to an extent that, in our murky atmosphere, would appear gaudy and unpleasing. The statues in the pediment, and the bas-reliefs on the metopæ and frieze, were brought out against a ground of azure blue; the tenia and regula, the fascias underneath the mutules; the cyma and ogee mouldings, and the lacunaria, were richly coloured; causing the columns, triglyphs, and principal parts of the cornice to appear more dazzlingly white from contrast. Along the architrave gilded shields were suspended, and between each shield was an inscription in brazen letters; thus, the Parthenon, standing on its lofty platform of rock, with its gleaming columns, its rich and harmonious colouring, its shields glittering like stars as they caught the sun's rays, would appear to the imaginative Greek a fitting abode for the virgin goddess, and was peculiarly appropriate to the gorgeous ceremonials of the Pagan religion.

The Erechtheion was commenced about 409 B.C., and completed 393 B.C. In this beautiful temple the Ionic order is carried to its greatest perfection. The plan is singular: it most resembles the prostyle, but with the addition of a portico at each side, one to the north, the other to the south, extending the western front. It is a double temple, dedicated to Minerva Pollias, as protectress of the city, and the nymph Pandrosos; it is also supposed to be the burial place of Cecrops.

A tradition from the mythology of Athens, quaintly related by Mr. Chandler, accounts for the union of the two shrines under one roof. "Minerva entrusted to Aglauros, Herse, and Pandrosos, a chest, which she strictly enjoined them not to open. It contained Erechtheus, or Erecthonius, an infant, the offspring of Vulcan and of the Earth, guarded by a serpent. Curiosity prevailing, the two elder sisters disobeyed. The goddess was gone to Pallene for a mountain, intending to blockade the entrance of the Acropolis. A busy crow met her on her return, and informed her what had passed, when she dropped the mountain, which was afterwards called Lycabetus; and, displeased with the officious talebearer, commanded that no crow should ever again visit the Acropolis. The guilty sisters were seized with a phrenzy, and threw themselves down one of the precipices; Pandrosos was honoured with rites and mysteries, she was joined with Minerva, and when a heifer was sacrificed to the goddess, it was accompanied with a sheep for Pandrosos."

The Erechtheion contained the most ancient statue of Minerva, said to have fallen from Heaven, in the reign of Erechthonius, king of Athens. Before this statue was the ever-burning golden lamp, the work of Callimachus. Here also was the sacred olive tree, called forth by Minerva in her contest with Neptune. In the small portico to the south, the entablature is supported by figures, generally called Caryatides; but as these seem to represent Athenian maidens in their Panathenaic costume, Canephoræ, or basket-bearers, is the more appropriate designation. Examples of such supporting figures are very rare in Greek art. The earliest is supposed to have been a brazen cratera, in the Temple of Juno at Samos, which was upheld by three kneeling colossi, 10 ft. 6 in. in height. It was dedicated about the year 640 B.C. by a Samian, of the name of Colænus, who was driven by contrary winds beyond the Pillars of Hercules; but having found a port at Tartessus, now Cadiz, and disposed advantageously of his goods, he and his crew, on their return, consecrated a tenth of their profit to the erection of this monument. A copy is supposed by Visconti to exist in a fountain, supported by three Sileni, in the Vatican.

Vitruvius gives the following account of the origin of Caryatides. "Carya, a city of Peloponnesus, took part with the Persians against the Grecian states. When the country was freed from its invaders, the Greeks turned their arms against the Caryans; and, upon the capture of their city, put the males to the sword, and led the women into captivity. The architects of that time, for the purpose of perpetuating the ignominy of this people, instead of columns in the porticoes of their buildings, substituted statues of these women, faithfully copying their ornaments and the drapery with which they were attired, the mode of which they were not permitted to change."

It is however generally thought that Caryatides owed their origin to the worship of Diana, and were intended to represent nymphs. In Lacedæmonia this goddess was worshipped under the name of Diana Caryatis; and the neighbourhood of Carya was said to have been consecrated to Diana and her nymphs. The celebrated Persian portico is only known to us by report; but there, apparently, the figures, like the Egyptian osirides, only stood in relief against the supporting pillar. They are said to have been portraits of Mardonia, Queen Artemisia, and other leaders of the Persian host, and erected with the spoils taken from them in battle. Figures thus introduced are seen at Thessalonica, in the building called the Incantada. This is not however of very ancient date. The entablature of the interior of the Cella in the Temple of Jupiter at Agrigentum, was supported by male figures, 25 ft. in height, called by the Greeks, Atlantes. They occupied the position of the upper row of columns in other hypæthral temples.

The columns of the eastern and northern porticoes of the Erechthion are exquisite in design and execution. The volutes are formed by a double spiral, and the lower band of the channel between takes a graceful curve. Beneath, between the volutes, is a plaited torus, and below this a wreath of honeysuckle ornaments. To the capitals of the eastern portico a beading, like a string of pearls, is added. The upper tori of the bases of the columns of this portico are fluted; while those in the northern portico are ornamented with a guilloche. The columns of the eastern or hexastyle portico are $9\frac{1}{2}$ diameters in height, and the intercolumniations are a fraction over two diameters, or nearly systile. Those of the tetrastyle, or northern portico, are rather less slender; and the intercolumniations are increased accordingly, being two and three quarters diameter, or nearly diastyle. These columns are raised upon a podium, as are also the Caryatides of the Pandroseion. The capitals of the columns at the angles were singularly ornamented with coloured stones, black, blue, and yellow, let into the small circles formed by the plating on the torus, between the volutes; and bronze plugs in the eyes of the volutes appear to have been intended to support further embellishment, probably garlands, with which it was the custom of the Greeks to adorn their temples on festive occasions. The eyes of the volutes in the Temple of Minerva Priene, are bored $2\frac{1}{2}$ inches in depth, most likely for the same purpose.

The Erechtheion was decorated with different coloured marbles. Fragments of columns of verd antique have been found in the interior; and the frieze of the eastern portico, as well as the tympanum of the pediment, is of grey Eleusinian stone. In the western wall of the cella are three windows, contracted towards the top. These divide four Ionic engaged columns, somewhat exceeding the semicircle, so that the last fluting is perfect. The channel of the fluting is slightly increased at the top, and diminished at the bottom, in order that the fillet attached to the wall may be perpendicular. In this temple is the only doorway now remaining amongst the ruins of Greece. Like the windows, it contracts towards the top: it has beautiful consoles, and is ornamented with open roses along the jambs, and wreaths of holly-leaf on the mouldings. Detailed drawings of this doorway are given by Mr. Inwood, in his work on the Erechtheion. The doors of Greek temples were generally constructed either of bronze or of wood, and perforated at the top to admit light. Mention however is made of the door of a temple in the wealthy city of Syracuse, which was of ivory and gold.

Before bidding farewell to the Acropolis, we must pause a moment before the great Propylea; though Phidias had the general superintendence of the works of Pericles, each building appears to have had its separate architect; the Propylea was the work of Mnasicles, and occupied five years in its erection. This structure, consisting of a vestibule with two wings, extended across the whole natural entrance to the Acropolis, a space of 168 feet. The propylæum or great vestibule, occupied 58 feet in the centre; the two wings enclosed the remainder, and extended 32 feet in front of the entrance. The portico of the vestibule was supported by six Doric columns, 5 feet lower diameter, and nearly 25 feet in height; the intercolumniations were 7 feet, excepting between the two centre columns, where a space of 13 feet was left, to allow of the passage of chariots: the level of the vestibule was gained by four steps. In the interior the roof was supported by six Ionic columns in two rows; this order was adopted in the interior on account of the greater elevation it allowed to the ceiling; this was laid upon marble beams, extending from the side walls to the columns, and from column to column: the length of the centre beams was 17

feet, of the lateral ones 22 feet. The vestibule was entered by five doors of bronze, the centre one corresponding in size to the middle intercolumniation: those at either side diminished both in height and width, and the two last were smaller still. The portico in the rear was similar to the one in front, except that it stood upon a higher level, being raised five steps above the entrance; one step in descent led from it to the platform of the Acropolis. The wings were finished at the extremities with antæ, and a frieze with triglyphs; in the flanks were three Doric columns *in antis*, each 3 feet diameter. In the northern wing was a chamber, in the southern an open gallery, with a narrow passage leading into the Acropolis by a postern gate. There is no doubt that the Propylea was intended as a means of defence as well as an ornamental entrance, and answered the same purposes as the pylons of the Egyptian temples. The Propylæa at Eleusis, Sunium, and elsewhere, were erected after this model, but consisted merely of a vestibule without wings, and formed a grand entrance to the peribolus of the Temple. The extent of the interior of the vestibule, and the quantity of light admitted, allowed great scope to the decorative artist. The lacunaria and mouldings of the Propylea at Athens were splendidly adorned with colours and gilding; the coffers of the soffits were spangled with gold stars on an azure ground, and the antæ enriched with a delicate wreath of ivy leaves. The roof and pediments of the Propylea were destroyed by the Venetians, A.D. 1687.

Next in importance to the sacred edifices were those appropriated to public amusements. The savage games of the amphitheatre were unknown to the refined and intellectual Greeks until after their subjugation to Rome. When the Roman Emperor caused gladiatorial combats to be exhibited in the Agora of Athens, the philosopher Demonax observed that it would first be necessary to throw down the altar to Mercy that stood there. Dramatic entertainments appear to have been the great delight of this highly cultivated people, and consequently in all Greek cities the ruins of extensive theatres are found. These structures were not used exclusively for the representation of the drama, however, for public assemblies were frequently held there; St. Paul addressed the Ephesians in the theatre; and the theatre of Syracuse, as we learn from ancient authors, was constantly so employed. Theatrical exhibitions originally commenced in a rural chorus celebrating in the fields the festivals of Bacchus and Ceres. Dramatic recitations first took place on a rustic wagon, next on a moveable wooden platform; but during a contest for the dramatic prize between Æschylus and Pratinas, the concourse of people flocking to witness the performance caused a serious accident, by the breaking down of the temporary theatre: this was the cause of one of more solid materials being erected; and painted scenery was now first introduced by Agatharchus, instructed by Æschylus. Vitruvius recommends that theatres should not have the concave part towards the south, on account of the heat, and that they should be built in a healthy situation. "For," says he, "those who frequent them, in company with their families, engaged by the interest they take in the representations, remain in fixed attention; whence it happens the pores of the body are exposed to the effects of the atmosphere, which, in the neighbourhood of marshes and spots otherwise unhealthy, is charged with vapours prejudicial to the human frame." The form of the Greek theatre was that of a segment of a circle, sometimes being more than the semicircle—sometimes with the sides continued in parallel lines, terminated by a parallelogram extended across the base. It consisted of three principal parts, the Coilon, containing the seats for the spectators; the Orchestra for the musicians, dancers, and chorus; and the Logeion or proscenium, for the principal performers. This was again divided into three parts; the Hyposcenium, on which the actors recited; the Scene itself, on which the decorations were exhibited; and the Parascenium, or enclosures behind and on each side of the Scene, containing apartments for the accommodation of the performers, and the preservation of the stage property. The Coilon was composed of rows of seats, rising one above another, separated at intervals by prœcinctiones, or passages, and by radiating flights of steps, and bounded at each extremity by a podium. This part of the theatre was almost always formed on the side of a hill, advantage being taken of the natural elevation, to save labour and expense; indeed, there are only two instances in Europe, and one in Asia Minor, of theatres built on level ground. The rows of seats between the passages were appropriated to different ranks of spectators, and above the upper corridor there was frequently a gallery for the accommodation of women and strangers. A covered portico extended round the summit of the Coilon, the entablature of which was level with the upper members of the elevation of the Scene. The Orchestra was generally concentric with the Coilon, and of considerable extent, as the drama alone was exhibited on the stage, other performances, such as singing and dancing taking place in the orchestra; hence the actors were respectively called either scenici, or thymelici. The Orchestra had a separate entrance; in the centre stood a platform, called the Thymele, which served as an altar, on which sacrifices were offered to Bacchus; and around were placed the tripods, crowns, and other prizes for the victorious dramatist or choragus. Steps led from the Orchestra to the Logeion; when the theatre was used as a place of public assembly, this part was occupied by the orators. Between the acts of the drama a curtain was let down before the Hyposcenium, or stage, during which time the chorus in the Orchestra entertained the spectators; underneath was the machinery used to produce thunder and other effects. The Hyposcenium, with its decorations, was generally constructed of wood, so that, of course, no vestiges of this part of any ancient theatre remain. The permanent Scene represented the exterior of a palace, and was used for tragic performances. As the Greeks never admitted strangers into the domestic privacy of their houses, it would have been deemed a breach of propriety to picture the interior on the stage. In the Scene were three doors; the centre one was magnificently decorated for the admission of the principal personage of the drama; near it was placed a circular altar, dedicated to Apollo, and a table spread with consecrated cakes and sweetmeats: the door on the right was plain, like that of a private dwelling—where the second actor entered; while that to the left, generally a mere opening, was for the inferior performers. When comic or satiric pieces were to be represented, painted scenes were added; in the former, exhibiting the exterior of a private residence, with windows and balconies; and the latter, pastoral subjects, with mountains, trees, and caves formed of grotto work. The Greek drama was recited rather than acted, three or four performers only appeared on the stage at one time, and these seldom crossed each other, or changed their places; the stage, therefore, was of little depth.

Vitruvius speaks of the Orchestra being divided into twelve equal portions, the same method practised by astrologers in dividing the zodiac into twelve constellations, "from a belief," he says, "that a musical concordance exists in the disposition of the stars." He also mentions modulating vases, of earth or metal, placed in two or three rows under the seats, to assist in extending the voice of the performer; they were in the form of an inverted bell, and were modulated to intervals according to musical proportion; so that when the voice was pitched to a certain interval, the vases vibrated in unison, and so carried on the sound. They were placed on pedestals, about 6 inches high, and an aperture was left in front of the seat, about 2 feet in length, and 6 inches in height. It is said, that when Lucius Mummius destroyed the theatre at Corinth, he dedicated a temple to Luna out of its spoils, and, amongst other things, brought away a number of these brazen vases. The Scene communicated with the lower chambers of the Parascenium by the before-mentioned doors; this part consisted of several stories. On the exterior was a portico with a double row of columns, where the audience found shelter in case of a sudden shower. The exterior columns were generally Doric; the interior Ionic, one-fifth higher. The columns were more slender, and the ornaments more fanciful and elaborate in the theatre than in sacred buildings, according with its festive intention. The space in front was laid out in walks, and planted with trees and flowering shrubs, so that the portico of the theatre was a pleasant place of resort for the loungers of ancient Greece. In early times there was no awning stretched over the Coilon, the voluptuous Sybarites having first introduced this luxury: the spectators, therefore, on sunny days, had to carry umbrellas, which must greatly have impeded the view; the ladies were attended by umbrella-bearers. The Dionysaic Theatre, at Athens, had seats for 30,000 persons: those of Sparta and Argos were 500 feet diameter; and the theatre in the Grove of Æsculapius, at Epidaurus, built by Polycletus, 360 feet diameter.

Near the great theatre there was generally an Odeion, so called from *odè*, a song; a smaller building, of similar form, but roofed; it was used for the purpose of musical entertainments, and for the rehearsals of the chorus. The Odeion of Pericles, at Athens, had a wooden tent-shaped roof, constructed with the masts and yards taken from the Persian ships; this was destroyed by Ariston (86 B.C.) that Sylla might not make use of the timber in his siege of the city. In Athens it was the custom for each of the demi, or tribes, to appoint a choragus, who was to conduct a chorus at the musical contest held at the Festival of Bacchus: the prize was a

tripod, and the victorious choragus usually erected a monument on which to place it; this was the origin of the street of tripods. Two of these choragic monuments are yet standing, those of Thrasyllus and Lysicrates; the former of the Doric, the latter of the Corinthian order. The following was the form of dedication: "Thrasyllus, son of Thrasyllus of Deceleia, dedicated the tripod, having, when he provided the chorus, conquered with men for the tribe Hippothoontis; Evius of Chalcis was musician, Neœchonus was archon, Caraidamus, son of Sotis, was teacher." The Corinthian capital of the monument of Lysicrates has been already described; the conical roof is thatched with marble tiles in the form of laurel leaves; from the apex rises an elaborate floral ornament, on which the tripod was placed. This elegant little monument was erected 335 B.C.

Besides the temples and theatres, ruins of other extensive structures are found in most of the cities of Greece. There was the Palæstra and the Gymnasium for the practice of athletic exercises; the Stadium for foot races, wrestling, throwing the disc, and other public games; and the Hippodrome for horse and chariot races. The Palæstræ were buildings containing baths, and apartments for instruction and other purposes, surrounded by porticoes. Sometimes, as at Ephesus, the porticoes were inclosed by a wall, forming what was called a cryptoporticus; sometimes, as at Alexandria Troas, they were open all round. Within the porticoes were spacious exhedræ or recesses, containing seats, where philosophers, rhetoricians, and other learned professors met to converse. In winter, or in stormy weather, the athletæ practised beneath the portico; a space was left along the centre 12 feet in width for the gymnastic sports, the margins being raised several steps above it as footways, so that persons could pass, or stand to watch the athletæ without being incommoded by them; in the Palæstræ were frequently double porticoes, called by the Greeks systylos; these were divided by open walks, planted with trees and furnished with seats. The Stadium was an open space in the form of a parallelogram, with one end terminating in a semicircle; the Hippodrome was similar in form, but of greater extent; a podium or spina, as it was called, adorned with altars and statues, extended along the centre; round this the chariots turned in the race. The Hippodrome at Olympia was the largest in Greece; here as many as forty chariots ran at one time. The Hippaphesis of this course, or place from which the horses started, was so celebrated, that the architect placed the following inscription on a statue he afterwards executed at Athens: "Kleöitas, son of Aristocles, made me, the same who first invented your Hippaphesis, O Olympia!" Pausanias has left us a description of this structure; he says, "The Aphesis presents the appearance of the prow of a ship, of which the beak, or embolus, is turned towards the course. At the side where the prow abuts on to the portico called Agnamptus, it becomes wider. A dolphin of brass is placed on a bar at the extreme point of the beak. Each side of the Aphesis is more than 400 feet in length; in these stalls are constructed, which those who enter for the horse race portion out by lot among themselves. Before the chariots and the horses a cord is stretched by way of a barrier. About the middle of the prow is an altar of unburnt brick, which, every Olympiad, is covered externally with dust; upon the altar stands a brazen eagle with its wings extended. When the person to whom the duty is intrusted has put in motion the machinery by which the eagle is directed, it springs up so as to become visible to all the spectators; then the brazen dolphin sinks to the ground; the cords which are on both sides of the portico of Agnamptus are let loose, the horses that are in these stalls advance first, and when they come in a line with those to which are allotted the stalls of the second rank, the cords that restrain these are also loosened, and the same order is observed by all the others until they are all drawn up in an equal line at the beak of the prow; and here follow the display of the skill of the charioteers, and of the swiftness of the horses."

Public business and traffic of all kinds was carried on in the Agora, a large space something between the great square or *place* of modern continental towns, and an oriental bazaar. The old Agora at Athens was situated in the inner Ceramicus, and extended over the hill of the Areopagus; here were warehouses and shops in different divisions, according to the trade carried on, and receiving their names from the commodities on sale. Here also were extensive porticoes or stoæ; that called the Pœcile, adorned with fresco paintings of the battle of Marathon, was the resort of the stoic philosophers, whence they took their name. Numerous statues of the heroes and benefactors of Athens adorned the place; to some of these a copy of every new law proposed was appended previous to discussion. Many important public buildings also stood within the limits of the Agora; among the rest the Bouleetereion, or council-chamber, where the senate of five hundred met to discuss measures before they were laid before the general assembly of the people in the Pnyx; and the refectory of the Prytanes or presidents of the assembly, where the most distinguished Athenian citizens were entertained at the public charge. In the centre of the Agora stood an altar dedicated to the twelve principal divinities; this was the point from which the different roads of Attica diverged, and from which distances were measured. The new Agora was to the north of the Acropolis, in the quarter called Eretria; near this was the Tower of the Winds, or Horologia of Andronicus Cyrrhestes, erected 159 B.C. It is a small octagonal building of the Corinthian order, surrounded by a frieze, on which figures emblematic of the winds are carved in bas-relief, one occupying each side. Beneath these lines are traced, with styles fixed above; the shadows thrown from the styles upon the lines told the hour of the day; when the sun was obscured, a clypsedra, or water-clock, in the interior of the building, answered the same purpose. The roof is but slightly elevated, and is composed of twenty-four blocks of marble, cut in the form of tiles, diminishing as they incline to the centre; on the summit a circular block of marble supported the figure of a triton holding a wand, so constructed as to move on a pivot and point in the direction of the wind.

Before speaking of the houses of the living I must make brief mention of the abodes of the dead. None but the greatest heroes were allowed a burial place within the city; but without the gates, each side of the road was lined with monuments. The most usual form was that of a pillar or stelé, bearing the name of the deceased, and often richly sculptured. The palmette, or Greek honeysuckle, is the device most frequently met with. As this ornament does not resemble any known flower, its origin has given rise to many speculations. The recent discoveries in Assyria have, however, thrown new light upon the subject, as we find there the same device in conjunction with the kneeling bull—indeed, with the bull prostrate before it; it is evident that it was some ancient symbol of fire-worship; nor does it require any very great stretch of imagination to suppose it to have been intended to represent the curl of the ascending flame. It was contrary to the principles of Greek art to use decoration without meaning; we may take it for granted, therefore, that as we find it so constantly represented on the stelé of tombs, it was with them also a sacred emblem. It is worthy of remark, that on the more ancient Greek sculptures the palmette is more formal, and decidedly less floral in character. The tendrils and other scrolls were doubtless added merely to give additional beauty after the traditional meaning was lost or disregarded. A more elaborate kind of sepulchre was that called Distega, or double-roofed, consisting of two square chambers; the lower apartment contained the cinerary urns, while in the upper relations and friends were accustomed to meet on anniversaries and stated occasions, to perform rites and pour libations to the manes of the dead. The decoration of sepulchres was at one period carried to so great an extent in Greece, that, soon after the time of Solon, a law was passed at Athens that no more labour should be bestowed upon any place of sepulture than ten men could perform in three days, and that the roof should be plain; the setting up of Hermæ, or statues of Mercury, was also forbidden. Long afterwards it was again enacted by Demetrius, the Phalerian, that no person should have more than one monument, and that the height of the pillar should not exceed three cubits.

Little is known of the private houses of the Greeks. For the most part strict republicans, they had no buildings that could claim the name of palaces. The dwellings of the greatest men were as simple as those of the humblest citizen. Demosthenes thought it a sufficient ground of accusation against Medias, that he had built a house at Eleusis by which all others were cast into the shade. To so great an extent was this simplicity carried under the severe laws of Lycurgus, that the Spartans were forbidden to use any other tool in the construction of their dwellings than the axe and the saw. When King Leotychides visited Corinth, noticing smoothly-wrought beams supporting the ceilings of the rooms, he asked if trees grew square in that country. The houses of the Greeks presented nothing but a plain wall and an entrance door towards the street, the windows opening to the interior courts. The rooms were small, and were merely for the purpose of eating and sleeping, the Greeks both transacting business and pursuing pleasure in the open air, under the numerous porticoes of the city, or amongst the groves of the Academy, Lyceium, and other public gardens. It was, no doubt, on account of the smallness of the rooms that the doors were made to open outwards: the person about to leave the house knocked first, to

give notice to those passing outside that the door was about to be opened. According to Vitruvius, the vestibule, cavœdium, and peristyles, were the only parts of the house where a stranger might enter uninvited. The master of the house alone was permitted to enter the gynæceum, or women's apartments. From the street entrance is a passage, terminated by gates. On one side of this is the stables; on the other the porter's lodge. This passage leads into a peristyle or open court, surrounded by a colonnade. This belongs to the gynæceum, where the mistress of the house occupied herself with weaving and embroidery, in the midst of her maidens. Next to this were the rooms common to the household, and those set apart for strangers. The hospitalia, or strangers' rooms, had a separate entrance-gate. Here the traveller was entertained, and enjoyed as much ease as in a modern inn; he was provided with supper and a bed on the evening of his arrival, and the following morning went on his way, after receiving presents of fruit, poultry, eggs, and other such produce. After this was the largest division of the house, containing the great peristyle, and the principal apartments, such as the banqueting rooms, pinacotheca, or picture gallery, &c. The eating rooms contained triclinia, on which the company reclined at their meals; whence the rooms took their name. The women never appeared at table with the men; and into some of the œci they were not even admitted, for which reason they were called andronis. Private houses were mostly built of brick, the walls being plastered or stuccoed, and the lacunaria constructed of wood. It is probable they had an upper story; but the situation of the staircase is unknown. Mosaic pavements have been occasionally discovered, supposed to have belonged to the courts of ancient dwellings. The well-known design of doves drinking from a tazza, is from a mosaic of this description. The great simplicity prevailing in private houses caused the attention of the artist to be wholly directed towards the decoration of temples, theatres, and other public buildings. Perhaps it was for this reason that artists were held in such great veneration by the Greeks, being regarded as men dedicated to the service of the gods and of their country.

For detailed information upon the subject of Greek architecture, I would refer the student to the valuable works published by the Dilettanti Society, and those of Mr. Stuart, Mr. Wilkins, and others, which cannot fail both to interest and instruct.

When I have the pleasure of resuming these lectures after the vacation, I shall begin with the subject of Architecture as practised by the Romans.

[The next lecture will appear in the October number of our *Journal.*—ED.]

LIST OF AUTHORITIES.

Vitruvius.—Histoire des Arts chez les Anciens, Winckelmann.—Topography of Olympia, Stanhope.—Encyclopedie Methodique.—Architettura Antica, Canina.—Antiquities of Ionia, Dilettanti Society.—Antiquities of Attica, Dilettanti Society.—Antiquities of Athens, Stuart and Revett.—Travels in Greece, Dr. Clarke.—Travels in Greece, Chandler.—Remarks on the Parthenon, Lucas.—The Erechtheion, Inwood.—Antiquities of Magna Græcia, Wilkins.—Antiquities of Sicily, Hittorf.—Topography of Athens, Col. Leake.

METEOROLOGICAL QUARTERLY REPORT.

Remarks on the Weather during the Quarter ending June 30, 1850. By JAMES GLAISHER, Esq., F.R.S., Hon. Sec. of the British Meteorological Society.

THE weather during the past quarter has been variable, and at times very unusual. The temperature of the air till April 21 was 4·3° above the average, and this period was free from frosts; from April 22 to May 16 there was an average deficiency of 5° daily temperature; from May 17 to June 9 the temperature was about its average value; it was 8° in excess on June 11, and 13° in defect on the 15th, and during the following night the temperature of the air in many places was below 32°, a very unusual circumstance for the season. From June 18th to the 26th the period was warm, the mean excess of temperature was 6°. Snow has fallen on several days during the past quarter.

The mean temperature of the air at Greenwich for the three months ending May, constituting the three spring months, was 46·6°, being of almost the same value as that of the average from the 79 preceding springs.

For the month of April was 48·5°, exceeding that of the average of the preceding 79 years by 2·8°, and exceeding that of the preceding 9 years by 1·0°.

For the month of May was 51·3°, being 1·3° less than the average of the preceding 79 years, and 3·1° less than that of the preceding 9 years.

For the month of June was 60·8°, exceeding that of the average of the preceding 79 years by 2·8°, and exceeding that of the preceding 9 years by 1·2°.

The mean for the quarter was 53·4°, exceeding that of the average of 79 years by 1·4°, and being less than that of the preceding 9 years by 0·3°.

The mean temperature of evaporation at Greenwich for the month of April was 45·4°; for May was 47·5°; and for June was 54·8°. These values are 1·7° *greater*, 3·0° *less*, and 0·1° *greater* than those of the averages of the same months in the preceding 9 years.

The mean temperature of the dew-point at Greenwich for the months of April, May, and June were 41·7°, 43·4°, and 50·1°. These values are 1·0° *greater*, 4·0 *less*, and 1·8° *less* respectively than the averages of the same months in the preceding 9 years.

The mean elastic force of vapour at Greenwich for the quarter was 0·318 inch, being less than the average from the preceding 9 years by 0·031 inch.

The mean weight of water in a cubic foot of air for the quarter was 3·6 grains. The average from the preceding 9 years was 3·8 grains.

The mean degree of humidity in April was 0·795, in May was 0·765, and in June was 0·702. The averages from the 9 preceding years were 0·808, 0·788, and 0·702 respectively.

The mean reading of the barometer at Greenwich in April was 29·594, in May was 29 714, and in June was 29·886. These readings are 0·114 *less*, 0·071 *less*, and 0·089 *greater* respectively than the averages of the same months in the preceding 9 years.

The average weight of a cubic foot of air for the quarter under the average temperature, humidity, and pressure, was 532 grains, being of the same value as that of the average of the preceding 9 years.

The rain fallen at Greenwich in April was 2·4 inches, in May was 2·3 inches, and in June was 1·0 inch. The falls for these three months on an average of 34 years are 1·7, 2·0, and 1·7 inches respectively. The average daily ranges of the readings of the thermometer in air at the height of 4 feet above the soil was in April 16·0°, in May was 18·9°, and in June was 26·0°. The averages for these three months from the preceding 9 years were 17·4°, 18 9°, 19·4° respectively.

The minimum readings of the thermometer on grass in April was at or below 32° on 12 nights, the lowest was 23°; was between 32° and 40° on 14 nights, and exceeded 40° on 4 nights; the highest reading was 44°. In May the readings were at and below 32° on 13 nights, the lowest was 15 ; they were between 32° and 40° on 11 nights, and on 7 nights the readings exceeded 40°. In June the readings were at and below 32° on 2 nights; the lowest was 29°; they were between 32° and 40° on 6 nights, and they exceeded 40° on 22 nights. At Cardington, as observed by S. C. Whitbread, Esq., the reading of the thermometer on grass in April was 12 nights, in May was 12 nights, and in June was 3 nights, below 32°.

The temperature of the Thames water, from the observations of Lieut. Sanders, R.N., Superintendent of the *Dreadnought* hospital-ship, was 48·4° in April, 54·3° in May, and 63·7° in June.

Solar halos were seen on April 1st at Greenwich, on the 2nd at Stone and Hartwell Rectory, on the 7th at Greenwich and Stone, on the 14th at Stone, on the 17th at Nottingham, on the 18th at Guernsey, Greenwich, and Nottingham; on the 19th at Stone and Nottingham, on the 21st at Hartwell Rectory, and on the 25th at Greenwich and Nottingham; on May 4th at Durham, on May 5 at Uckfield, on the 7th at Durham, on the 13th at Uckfield, on the 14th at Hartwell Rectory, on the 19th at Durham, on the 23rd and 26th at Hartwell Rectory, and on the 28th at Nottingham; on June 2nd at Nottingham and Whitehaven, on the 3rd at Nottingham, on the 4th at Greenwich, Stone, Hartwell Rectory, Nottingham, Stonyhurst, and Durham; on the 5th at Stone, on the 8th at Hartwell House, on the 9th at Stone, Rose Hill (Oxford), and Nottingham; on the 10th at Southampton, Stone, Hartwell House, Cardington, Rose Hill (Oxford), Norwich, and Nottingham; on the 11th at Stone, Rose Hill, Nottingham; on the 12th at Nottingham, on the 14th at Cardington, on the 16th at Stone, Rose Hill (Oxford), and Nottingham; on the 17th at Stone and Aylesbury; on the 18th at Aylesbury, on the 20th at Stone and Nottingham, on the 21st at Stone and Nottingham, and on the 29th at Uckfield and Nottingham.

Lunar halos were seen on April 16th and 17th at Hartwell Rectory, on the 19th at Wakefield, on the 20th at Liverpool, on the 21st, 22nd, and 23rd at Hartwell Rectory, on the 24th at Stonyhurst; on May 20th and 22nd at Uckfield, and on the 26th at Stone; on June 16th at Stone and Hartwell Rectory, on the 18th at Stone, on the 20th at Guernsey, Stone, Hartwell Rectory, and Radcliffe Observatory, Oxford; on the 21st at Jersey, Stone, and Hartwell Rectory; and on the 25th at Uckfield.

Paraselenæ were seen on May 28th at Durham, and on June 20th and 21st at Stone and Hartwell Rectory.

Parhelion was seen on May 21st at Nottingham.

Auroræ Boreales were seen on April 5th at Whitehaven, on April 6th at Durham, on May 12th at Aylesbury, Oxford, Stonyhurst, and Durham; on June 5th at Nottingham, on the 13th at Hartwell House, Ratcliffe Observatory, Oxford, and at Rose Hill, near Oxford; on the 26th near Manchester, on the 27th at Nottingham and at Chesterfield.

Meteors.—At Stone on April 10, at 10 p.m., a meteor shot from Jupiter to γ Leonis; on May 2, at 10 p.m., a meteor shot from Virgo about 4° from Jupiter, and went as far as Jupiter; on May 29, at 10h. 5m. p.m., a meteor shot from α Cygni southwards; on June 4, at 11h. 28m. p.m., a meteor shot from α Ursa Minor (Polaris) to δ Ursa Major; on the 16th, at 0h. 25m. a.m., a meteor shot from the west of β Cassiopeæ, and went 4° north; on the same night, at 0h. 40m. a.m., a splendid meteor, larger than a star of the first magnitude, shot from the west of Capella 10° east of due north,

and about 15° above the horizon, and went in a westward direction near to the star 31 Lyncis, leaving a train of blue light of about 20°; a few seconds after a small meteor shot from above Polaris to Cassiopea; on the same night, at 0·45 a.m., a meteor shot from β Serpentis, and went about 5° south; at 1h. 3m. a.m. a meteor shot from ϵ Bootes to Arcturus; at 1h. 20m. a.m. a meteor as large as a star of the first magnitude, and of a beautiful red colour, shot from ϵ Ursa Major passed by α Ursa Major, and went as far as γ Ursa Major; on the 20th, at 11h. 42m. p.m. a meteor shot between α Lyrœ and α Cygni; on the 24th, at 11h. 30m. p.m., a meteor, as large as a star of the first magnitude, shot from Arcturus, and went 20° magnetic west, leaving a train of blue light.

On June 4th, at Hartwell Rectory, a small meteor was seen from Polaris to the Pointers, at 11h. 30m. p.m.; on the 21st, a meteor shot from α Lyrœ to α Cygni at 11h. 42m. p.m.; on June 24th a meteor was seen from Arcturus to within 10° of the horizon at 11h. 30m. p.m.

At Nottingham, on May 1st, at 10h. 33m. a meteor of the size of second magnitude star fell slowly down from 30° above south horizon at an angle of 40° to west; another fell downwards 5° south of Jupiter; May 30th, at 10h. 38m., a meteor, size second magnitude, passed nearly horizontally 1½° under Vega, moving to south; June 1st, a globe meteor, size of Jupiter, but less bright, of a red colour, having a well-defined disc, moved from γ through φ Cassiopeæ, ended 30° east of α Persei, duration 1½ minute; on the 3rd another, size third magnitude, blue colour, ill defined, passed from α Cygni through Lacretan at 10h. 30m., and at 10h. 4m. a nearly similar one from λ Draconis through η Draconis.

Thunder-storms occurred on April 2 at Wakefield, Leeds, Liverpool, Stonyhurst, and Whitehaven; on the 8th at Uckfield; on the 10th at Aylesbury; on the 11th at Hartwell Rectory, Stone, Cardington, and Saffron Walden; on the 12th at Uckfield, Greenwich, London, and Saffron Walden; on the 13th at Greenwich; on the 17th at Norwich; on the 20th at Holkham, Nottingham, and Exeter; on the 23rd at Hawarden; on May 7 at Uckfield; on the 13th at Leeds and Hawarden; on the 17th at Uckfield; on the 19th at Derby; on the 22nd at Stonyhurst; on the 23rd at Stone, Hartwell Rectory, Hartwell House, Leinslade (Bucks), Rose Hill (Oxford), Cardington, Saffron Walden, Derby, Nottingham, Liverpool, Leeds, and Manchester; on the 24th at Hartwell House, Rose Hill (Oxford), and Radcliffe Observatory, Oxford; on the 26th at Norwich; on the 27th at Leeds, Manchester, Durham, and North Shields; on the 30th at Hartwell House, Liverpool, and Stonyhurst; on the 31st at Stone, and Rose Hill, Oxford; on June 5th at Wakefield, North Shields, and Durham; on the 6th at Hartwell House, Hartwell Rectory, Leeds, Stonyhurst, Durham, and Whitehaven; on the 7th at Leeds; on the 12th at Helston; on the 13th at Uckfield; on the 16th at Durham; on the 17th at North Shields; on the 25th at Wakefield and Leeds; on the 26th at Guernsey, Helston, Falmouth, Truro, Exeter, Uckfield, Southampton, St. John's Wood, Greenwich, Stone, Aylesbury, Hartwell House, Hartwell Rectory, Leinslade, (Bucks), Saffron Walden, Radcliffe Observatory (Oxford), and Cardington; on the 27th at Guernsey, Jersey, Exeter, Chichester, St. John's Wood, Uckfield, and Hartwell House. Of these storms that of the 26th of June was the worst; it was described by M. J. Johnson, Esq., of Oxford Observatory, as the most violent storm of thunder and lightning ever remembered there; it began about 2·30 p.m., and lasted till about 4·30 p.m. Two college towers were struck by lightning: no life was lost. But he had heard of five persons (three children) who were thrown down by the violence of the lightning; there appears to have been two storms, one succeeding the other after an interval of about 30 minutes. Mr. Johnson remarks, "I was not here myself, but the storm has been described to me by two trustworthy persons as terrific. As far as I can make out, the storm passed over the town in a N.N.E. direction."

At Hartwell Rectory, the Rev. C. Lowndes states, that on the 26th June thunder was heard at 1·30 p.m., and at 3 p.m. there was a heavy storm with thunder and lightning; it continued stormy during the evening and night.

At Hartwell House, Mr. Horton says that on June 26th a mansion near Thame, called Thame House, about ten miles from here, was set on fire by the lightning.

At Truro, Dr. C. Barham says, "The thunder-storm on June 21st was rather severe, but more so a few miles to the northward; eleven sheep were killed by the lightning in one field, and four in a neighbouring one about ten miles to the north-east; the rain was not very heavy, and there was no hail. There was a fall of 16° of temperature between 1 and 5 p.m., and the weather has continued unsettled, with showers and squally from that time to the present (July 3)."

At Exeter, Dr. Shapter says that, for three days previously to June 26th, the atmosphere had gradually become hot and sultry, and at 4 p.m. on that day it became exceedingly oppressive. Distant thunder was then heard, and heavy rain clouds came up with a light wind from the south; at 6 p.m. the storm reached Exeter, the lightning was constant and vivid. Heavy rain fell for two hours, when the storm moderated and passed on and the wind shifted rather suddenly till 6 p.m. It reached Bridgewater at 9 p.m. The electric telegraph at the South Devon Railway was rendered useless for several hours, and the trains consequently delayed. Rain fell to the depth of 1·21 inch during the storm.

At Uckfield, C. L. Prince, Esq. says, on the 26th, at night, there was a very severe thunder-storm, and that the electric fluid struck a house in that place, and shattered a portion of the roof, burnt some clothes, &c.; but injured no one, although there were thirty persons under the roof at the time.

At Southampton, John Drew, Esq., F.R.A.S., says that rain fell to the depth of 1·96 inch on June 26th.

Thunder was heard, but lightning was not seen, on April 11 at Rose Hill (Oxford) and Saffron Walden; on the 12th at Saffron Walden and Norwich; on the 17th at Hartwell House; on the 20th and 21st at Nottingham; on May 7th at Guernsey; and the 13th at Cardington, Stone, and Aylesbury; on the 17th at Nottingham; on the 18th at Wakefield and Nottingham; on the 19th at Cardington and Nottingham; on the 21st at Exeter and Hawarden; on the 22nd at Aylesbury and Holkham; on the 23rd at Aylesbury, Norwich, Holkham, Oxford, Wakefield, and Stonyhurst; on the 25th and 26th at Hawarden; on the 27th at Guernsey, Wakefield, and Stonyhurst; on the 31st at Hartwell Rectory, Leinslade (Bucks), Cardington, Oxford, Liverpool, Stonyhurst, and Whitehaven.—On June 5th at Nottingham and Dundee; on the 6th at Stone and Nottingham; on the 9th and 11th at Stone; on the 12th at Helston; on the 16th at Stonyhurst; on the 25th at Nottingham; on the 26th at Jersey, St. John's-wood, Wakefield, and Nottingham; on the 27th at Stonyhurst; and on the 28th at Jersey.

Lightning was seen, but thunder was not heard, on April 2nd at Stone and Stonyhurst; on the 20th at Nottingham. On May 2nd at St. John's-wood. On June 5th at Nottingham; on the 26th at St. John's-wood; on the 27th at St. John's-wood and Aylesbury; on the 28th at Aylesbury and Cardington; on the 29th at Aylesbury.

The daily *horizontal movement of the air* was 110 miles in April, 96 in May, and 90 in June.*

Wheat in ear, at Aylesbury on June 9th; at Leinslade (Bucks) and Hawarden on the 10th; at Holkham on the 11th; at Cardington on the 12th; at Helstone, Stone, Hartwell, and Oxford on the 16th; at Nottingham on the 20th; at Leeds on the 24th.

Wheat in flower, at Jersey on June 8; at Uckfield on the 10th; at Guernsey on the 16th; at Holkham and Stonyhurst on the 20th; at Stone on the 21st; at Hawarden on the 22nd; the white at Wakefield on the 22nd, and the red in the same field on the 26th; on the 23rd at Helston, Hartwell, Leinslade, and Derby; on the 25th at Cardington; on the 26th at Nottingham; on the 28th at Rose-hill, near Oxford; on the 30th at Leeds.

Hay began to be gathered, at Hartwell and Stone on the 18th; at Hawarden and Whitehaven on the 24th; at Durham on the 27th.

The common Lilac in flower, at Jersey on April 22; at Guernsey and Helston on the 25th; at Uckfield on May 5; at Hartwell House and Wakefield on the 11th; at Aylesbury on the 12th; at Oxford on the 13th; at Stone on the 15th; at Hawarden on the 16th; at Nottingham on the 19th; at Cardington on the 20th; on the 22nd at Leeds, at Derby, and Holkham on the 23rd; at Stonyhurst on the 27th; at Durham on the 30th.

The *Cuckoo* was first heard at Uckfield on April 11; at Stone on the 12th; at Whitehaven on the 16th; at Hartwell on the 21st.

The first *Swallow* was seen at Stone on April 3; at Whitehaven on the 18th; at Nottingham on the 20th; at Hartwell Rectory on the 22nd; at Durham on the 21st of May.

The following observations of natural phenomena were taken at Highfield House, near Nottingham (being nearly in the centre of England), by Edward J. Lowe, Esq., F.R.A.S.

April 1. Willow wren arrived
.. 10. Ribes sanquineum in full glory; damson plums just in bloom
.. 11. Sand martin arrived
.. 14. Asparagus ready to cut; found nest of longtail'd titmouse
.. 16. Whiteheart cherry just in flower
.. 18. Wild cowslip in flower
.. 20. Swallow arrived; corncrake first heard
.. 21. Snowy mespulis in flower; nightingale's first song; Daphne cueorum just in flower
.. 28. Hedges in full leaf
.. 30. Some chesnut trees in nearly full leaf
May 1. Daphne japonica in full flower
.. 4. Sycamores in full flower
.. 5. Apple (Maltster) in full blossom
.. 6. Morella cherry in full blossom
.. 8. Beech in full leaf
.. 9. Swift arrived
.. 10. White broom just in flower
.. 13. Apples in full blossom; cuckoo heard
.. 16. Spotted flycatcher arrived; double gorse in full flower
.. 17. White lilac has few blossoms expanded; hawthorn do.; wheatear building a nest; rhododendron caucasicum in full bloom
.. 19. Apples generally in full blossom
.. 22. Purple lilacs in flower
.. 23. Laburnum in full flower; double blossomed cherry in flower
.. 24. Whinchat nest with eggs
May 25. Lilacs in full glory
.. 26. Pink hawthorn just in flower
.. 28. Oak nearly in leaf; hybrid rhododendron in flower
.. 29. Yellowhammer's nest with eggs; reed sparrow's do.
.. 30. Flowing ash in flower
.. 31. Lupinus polyphyllus in flower; flycatcher's nest with eggs; tree peony just in flower; lily of valley in flower
June 2. Snowball tree in flower
.. 7. Lilacs out of flower
.. 9. Woodbine in flower
.. 12. Japonica in full flower
.. 13. Syringer in flower
.. 14. Laburnums out of flower
.. 16. Rosa canina just in flower
.. 13. Wheat just showing ear.
.. 16. Leonicera pubisceus just in flower; tree peony out of flower; peas ready to gather
.. 17. Rose (Mrs. Bosanquet) just in flower; elder just in bloom
.. 20. Strawberries just ripe; acaria in flower; hay, some housed to day, very little as yet cut; barley just coming in ear; wheat in full ear
.. 24. Rose (Persian yellow) in flower; kalmia latifolia var. albu in full flower
.. 26. Portugal laurel in full flower; wheat in flower
.. 31. Roses of all kinds in full glory.

The following table contains the mean quarterly values of the several subjects of meteorological investigation during the past quarter.*

* See the *Philosophical Magazine* for August 1850, for tables of the direction of the wind.

† For the monthly values see the Quarterly Report of the Registrar-General.

Meteorological Table for the Quarter ending June 30th, 1850.

The observations have been reduced to mean values, and the hygrometrical results have been deduced from "Glaisher's Tables."

NAMES OF THE PLACES.	Mean Pressure of Air reduced to the level of the Sea.	Mean Temperature of the Air.	Highest reading of the Thermometer.	Lowest reading of the Thermometer.	Mean Daily Range of Temperature.	Mean Monthly Range of Temperature.	Range of Temperature in the Quarter.	Mean Temperature of the Dew-Point.	WIND. Strength.	WIND. Direction.	Mean Amount of Cloud.	RAIN. Number of Days on which it fell.	RAIN. Amount Collected.	Mean weight of Vapour in a cubic foot of Air.	Mean additional weight required to saturate a cubic foot of Air.	Mean degree of Humidity.	Mean whole amount of Water in a Vertical Column of Atmosphere.	Mean Weight of a cubic foot of Air.	Height of Cistern of Barometer above the Level of the Sea.	NAMES OF THE OBSERVERS.
	in.	°	°	°	°	°	°	°					in.	gr.	gr.		in.	grs.	ft.	
Guernsey	29·575	52.9	75·0	41·0	10·2	22·6	34·0	48·3	1·5	W.	4·5	46	7·2	4·1	0·6	0·864	4·9	535	123	Dr. Hoskins, F.R.S.
Helston	29·455	52·2	86·0	32·0	16·1	35·3	54·0	48·6	1·6	S.W.&N.W.	5·4	34	8·4	3·9	1·4	0·747	5·0	531	106	M. P. Moyle, esq.
Falmouth	..	52·0	84·0	34·0	16·4	35·0	50·0	..	1·4	Var.	6·5	41	8·7	..	..	..	..	..	120	L. Squire, esq.
Torquay	..	54·1	75 0	40·0	11·6	26·0	35 0	46·8	1·4	W. & N.E.	..	42	8·8	4·5	1·1	0·758	..	535	..	E. Vivian, esq.
Truro	..	52·6	83·0	28·0	15·6	37·3	55·0	46·6	1·1	N. & S.W.	6·0	38	7·7	3·8	1·0	0·800	4 7	536	..	Dr. Barham
Exeter	29·542	52·8	86·2	31·6	19·8	40·6	54·6	47·5	1·8	Var.	3·7	43	9·0	4·0	0·9	0·813	4·7	533	140	Dr. Shapter
Chichester	..	52·3	81·0	33·0	16·6	37·3	48·0	.	..	Var.	..	..	7·7	..	..	..	..	..	..	W. Hills, esq.
Uckfield	29·578	53·8	87·0	25·0	21·5	48·3	62·0	47·7	..	S.W.	..	38	9.1	3·7	1·4	0·704	4·5	532	180	C. L. Prince, esq.
Southampton	29·574	53·5	82·0	30·3	..	38·0	51·7	49·3	0·4	..	6·0	41	10·1	4·2	1·1	0·799	5·0	537	55	John Drew, esq., F.R.A.S.
Royal Observatory, Greenwich	29·598	53·5	85·1	31 7	20·3	42·5	53·4	45 1	..	S.W.	..	45	5·6	3·9	1·2	0 754	4·4	532	159	The Astronomer Royal
Maiden Stone Hill, Greenwich	29·582	52·7	81·3	30·5	17·5	38·5	50·8	48·5	..	Var.	6·6	43	5·6	4·1	0·8	0·847	5·0	533	107	Mr. William Ellis
St. John's Wood	29·591	53·0	81·7	32·0	18·1	40·5	49·7	42·4	1·6	..	6·4	44	5·7	3·3	1·4	0·712	4·0	533	150	George Leach, esq.
Chiswell-street, London	29·595	55·6	77·0	40 0	12·1	29·3	37 0	46·9	..	..	..	40	5·6	3·8	1·3	0·734	4·7	530	170	David Slate, esq.
Aylesbury	29 663	53·2	86·0	30·0	21·0	44·0	56·0	43·8	0 6	S. & W.	..	41	5·1	3·5	1·4	0·719	4·2	530	284	Thomas Dell, esq.
Stone Observatory	29 563	51·9	82·5	29·9	19·5	41·3	52·6	44·4	0·9	S.W. & N.E.	..	43	5·4	3 5	1·0	0 777	4·3	529	320	Rev. J. B. Reade, F.R.S.
Hartwell (near Aylesbury)	29·558	52·6	85·0	29·0	21·4	43·1	56·0	45·3	1·2	S.W. & N.E.	7·0	47	4 0	3·7	1·1	0·778	4·4	532	250	Dr. Lee, F.R.S.
Hartwell Rectory	29 570	51·9	84·2	31·0	19·2	40·6	53·2	44·1	0·8	S.W.&N.W.	5·8	46	3·9	3·5	1·1	0·762	4·4	530	290	Rev. C. Lowndes, F.R.A.S.
Leinslade (Bucks)	..	52·9	85·0	32·0	18·7	40·7	53·0	..	..	N.E.	..	47	4·8	..	..	..	..	..	313	John Osborn, esq., Junr.
Radcliffe Observatory, Oxford	29·577	52·0	..	..	..	..	..	47·3	2·1	N.E. & S.W.	7·3	40	6·3	3·9	0·7	0·850	4·7	531	210	M.J.Johnson, esq., F.R.A.S.
Rose Hill (near Oxford)	29·587	52·5	86·0	30·9	19·1	41·9	55·1	47·3	2·0	S.W.	7·5	45	..	4·0	1·0	0·834	4·9	530	270	Rev.T.Slatter,esq.,F.R.A.S.
Cardington	29·567	52·5	83·0	30·8	19·2	41·6	52 2	45·6	1·2	N.E. & S.W.	7·0	39	4·9	3·7	1·0	0·778	4·5	534	100	S.C.Whitbread,esq.F.R.A.S.
Norwich	29·518	51·2	80·0	30·0	16·3	38 6	50 0	45·9	..	S. & S.W.	7·0	30	5·2	3·7	0·8	0·840	4·5	536	23	W. Brooke, esq., F.R.A.S.
Holkham	29 583	51·3	81·2	30 3	15·7	42·0	50·9	43·9	1·2	N.E.	6·3	36	4 1	3 5	1·0	0·785	4 2	537	39	The Earl of Leicester
Nottingham	29 518	52·4	87·2	29·8	20·8	45 0	57·4	45·5	0·6	N.E.	7·0	50	4·9	3·7	1·0	0 789	4·5	532	103	E. J. Lowe, esq.
Derby	..	50·9	80·0	29·0	17 8	37·7	51·0	46·7	..	..	..	51	5 2	3·8	0·7	0·848	4·6	535	..	John Davis, esq.
Manchester	29·569	52·6	..	..	..	..	..	45·8	..	S.W.	6·6	46	5·6	3·8	1·0	0·790	4·6	533	144	G. Vernon, esq.
Hawarden	29·550	51·1	75·5	32·4	13·5	33·5	43·1	43·7	2·0	S.	7·0	38	5·1	3 5	1·0	0·782	2·9	531	260	Dr. Moffatt, F.R.AS.
Liverpool	29·536	52·9	74·7	36·7	10·6	26·7	38.0	46·7	1·2	Var.	6·2	38	4·2	3·9	0·9	0·819	4·7	536	37	John Hartnup,esq.,F.R.A.S.
Wakefield	29·550	50·9	84·0	26·0	20 0	42·7	58·0	44·2	1·9	Var.	7·2	55	5·0	3·6	1 0	0·744	4 2	535	115	W. R. Milner, esq.
Leeds	29·597	50·5	80·0	30·0	17·6	39 0	50·0	44·3	1·4	..	5 0	46	5·1	3·5	0·8	0·820	4·3	531	125	C. Charnock, esq.
Stonyhurst	29·578	49·6	79·0	27·9	16·7	36·9	51·1	42·3	1 3	W.	7·7	47	9·5	3·5	0·6	0·799	4 3	530	381	Rev. A. Weld, F.R.A.S.
York	29·562	50·4	77·0	31·0	15·3	33·7	46·0	44·4	..	N.E. & S.W.	..	42	4·5	3·6	0·9	0·798	4·3	536	50	John Ford, esq.
Whitehaven	29·531	50·3	78·5	32·5	12·4	33·2	46·0	44·8	1·9	S.W.	..	43	6·4	3·6	0·6	0·860	4·3	537	90	J. F. Miller, esq., F.R.S.
Durham	29·424	49·1	76·8	27·1	14·1	39 8	49·7	44·8	0·9	Var.	6·6	46	4·8	3·6	0·7	0·839	4.4	531	340	R. C. Carrington, esq.
Newcastle	..	50·6	80·0	32·0	12·9	32·3	48·0	44·4	..	S.E. & N.W.	..	33	..	3·6	0·9	0·804	4 3	536	..	G. Muras, esq.
North Shields	29·584	48·1	73·7	33·0	10·4	29·5	40·7	44·6	..	Var.	6·0	61	5·5	3·6	0·4	0 934	4·3	540	90	R. Spence, esq.
Glasgow	..	49·7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	Dr. R. D. Thomson

The mean of the numbers in the first column is 29·561 inches, and it represents that portion of the reading of the barometer due to the pressure of air; the remaining portion, or that due to the pressure of water, is 0·322 inches: the sum of those two numbers is 29·874 inches, and it represents the mean reading of the barometer for the quarter ending June 30, 1850.—By taking the mean of the numbers in the preceding Table for those places situated between different parallels of latitude, the following Table was formed.

Quarterly Meteorological Table for different Parallels of Latitude.

PARALLELS OF LATITUDE, &c.	Mean Temperature of the Air.	Mean of Highest Reading of the Thermometer.	Mean of Lowest Reading of the Thermometer.	Average Daily Range of Temperature.	Average Monthly Range of Temperature.	Average Quarterly Range of Temperature.	Mean Temperature of the Dew-Point.	Mean amount of Cloud.	RAIN. Average Number of Days.	RAIN. Average Fall.	Mean Weight of Vapour in a cubic foot of Air.	Mean Additional Weight required to saturate a cubic foot of Air.	Mean degree of Humidity.	Mean whole amount of Water in a vertical Column of Atmosphere.	Mean Weight of a cubic foot of Air.	Mean Height above the Sea.
	°	°	°	°	°	°	°			in.	gr.	gr.		in.	gr.	ft.
In the Counties of Cornwall and Devonshire	53·5	81·5	34·4	13·3	32·8	47·1	47 6	5·2	40	8·3	4·1	1·0	·796	4·8	534	122
South of Latitudes 52°	53·0	83·4	31·2	18·7	40·2	52·2	46·0	6·7	43	6·0	3·8	1·1	·773	4·5	532	230
Between the Latitudes of 52° and 53°	52·0	82·3	30·0	17·9	41·0	52·3	45·5	6·8	41	4·8	3·7	0·9	·808	4·5	535	66
Between the Latitudes of 53° and 54°	51·0	79·3	29·5	16·6	37·2	49·6	44·1	6·7	46	5·8	3·6	0·9	·789	4·1	533	179
Liverpool and Whitehaven	51·6	76·6	34·6	11·5	30·0	42·0	45·7	6·3	40	5·3	3·8	0·8	·840	4·5	536	37
Durham, North Shields, and Newcastle	49·3	76·8	30·7	12·5	33·9	46·1	44·6	6·3	47	5·2	3·6	0·7	·859	4·3	536	340
Glasgow	49·7	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..

The highest reading of the thermometer in air was 87° at Uckfield and Nottingham; and the lowest readings were 25° at Uckfield, and 26° at Wakefield. The extreme range of temperature during the quarter, in England, was therefore about 60°

The least daily ranges of temperature took place at Guernsey, Liverpool, and North Shields—their mean value was 10·4°; and the greatest occurred at Uckfield, Aylesbury, and Hartwell, and their mean value was 21·3°.

The least monthly ranges of temperature occurred at Guernsey, Torquay, and Liverpool—their mean value was 25·1°; the greatest took place at Uckfield, Aylesbury, and Nottingham—their mean value was 45·8°.

Rain fell on the least number of days, at Helston, Holkham, and Norwich—the average number at these places was 33. It fell on the greatest number of days at North Shields, Wakefield, and Derby—the average number at these places was 56. The places at which the largest falls took place were Southampton, Stonyhurst, and Exeter; the average amount at these places was 9·5 inches. The smallest falls occurred at Hartwell, Holkham, and Liverpool, and their average was 4 inches.

OPEN TIMBER ROOFS.

Glances at the Structural Principle of the Roof of Westminster Hall, and the indications of a disused Method of Supporting Roofs, afforded by existing evidences in this Country, and analogous Continental Examples. By Thomas Morris, Esq., Architect. (Paper read at the Royal Institute of British Architects, June 24th.)

Having a few years ago, in a paper to which you did me the honour to listen, treated on mediæval wooden roofs, and endeavoured to exemplify the structural principle of that of Westminster Hall, I have not read with indifference some recently published adverse opinions; and the grateful sense I entertain of your indulgence on former occasions, leads me, though with much diffidence, to bring a few remarks, thus directly, under the notice of gentlemen so highly qualified to exercise a judgment on the subject.

As the opinions alluded to arose from the review of a popular and very useful collection of open timber church roofs, it may be at once stated, that these are so inferior in size and scientific development to the finer domestic specimens (the boldest ecclesiastical example scarcely exceeding thirty feet, while Westminster Hall is sixty-eight feet wide), that I regard the volume in question, and its authors, as perfectly unobnoxious to remark, in a critical consideration of the matter.

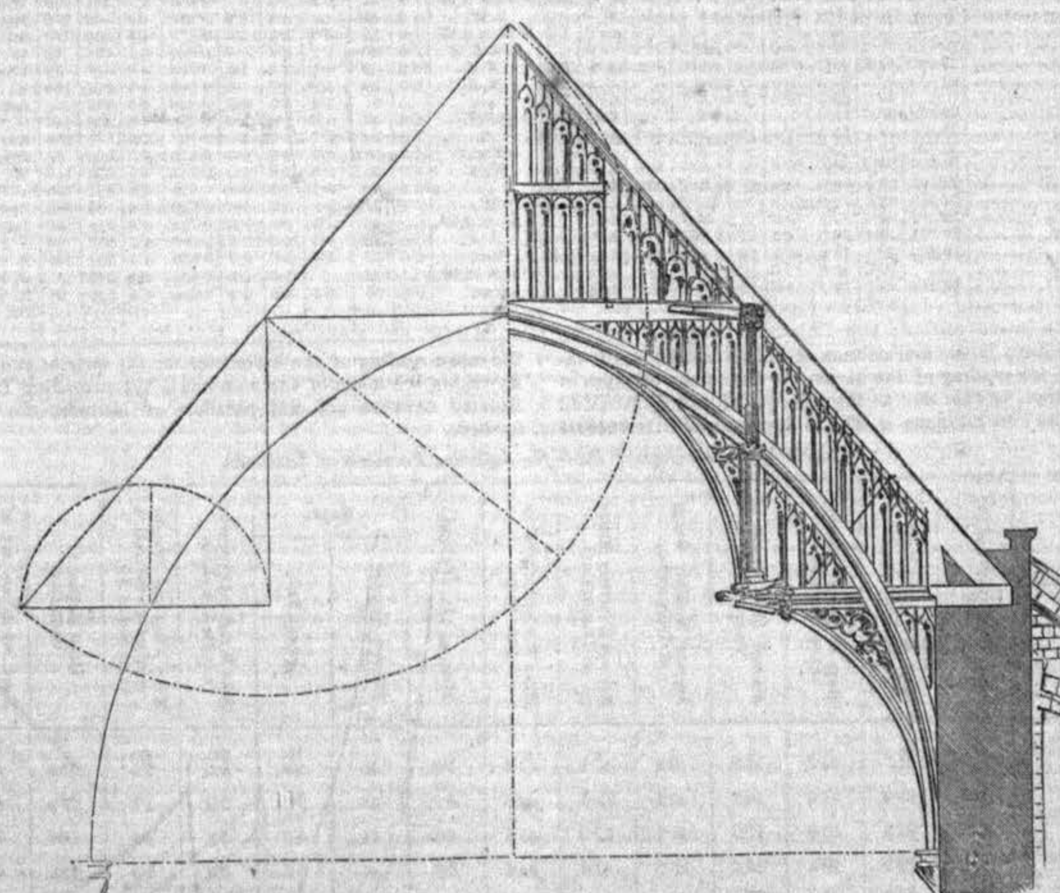
Those, indeed, who, from a conviction of the highly suitable and effective character of the open wooden roof for sacred, as well as civil edifices, would wish to revive and extend its application at the present time on true principles, will, I think, prosecute their object, with the fairest aim at excellence, by the diligent examination of those stupendous examples devoted to secular uses, in which the resources of art are most fully displayed. They will thus be best prepared to impart intrinsic merit to ecclesiastical works, too often left to rest their claim for respect on embellishments received from the carver or the colourist.

Had we examples of this latter kind only, notwithstanding the poetically typical significance and elaboration of detail possessed by many, the charge against our ancestors of a total failure to assimilate open roofs with the compressible architecture, or that called Gothic, might have remained uncontroverted; but, fortunately, we have instances of the most successful treatment, and of such none are more worthy of admiration, both for unapproached magnitude and ability of contrivance, than that of Westminster Hall. A recognition of the true system of its construction is calculated to be highly conducive to the progressive excellence of such works, and I shall esteem it a great satisfaction to be, however humbly, useful in so desirable a result.

Two authorities condemnatory of this roof have been brought more prominently forward—namely, Mr. Bartholomew and Dr. Robison. The first of these says, "No work on the earth perhaps exhibits more excellence of workmanship, and perhaps none shows more assiduity and skill of an inferior kind to obviate the thrusting power of the roof, but the whole being constructed on false and unscientific principles, it is in vain that this want of science is concealed by intricacy of framing and excellence of workmanship." If I am not mistaken, the writer here quoted has been entirely misled by the intricacy of the merely subordinate panelling or tracery; but as this will presently be more fully entered into, I shall proceed to Dr. Robison's view of the case.

"Westminster Hall," he says, "exhibits a specimen of the false taste of the Norman roofs. It contains the essential parts indeed, very properly disposed: but they are hidden, or intentionally covered, with what is conceived to be ornamental, and this is an imitation of stone arches, crammed in between slender pillars, which hang down from the principal frames, trusses, or rafters. In a pure Norman roof, such as Turnaway Hall, the essential parts are exhibited as things understood, and therefore relished."

It is surprising that a paragraph, betraying such extreme ignorance of dates and architectural characteristics, should have emanated from a writer of the Doctor's standing, even in the last century, and yet more astonishing that it should be put forward by a professional critic of the present day. It clearly shows, however, the impression that the internal parts of the truss really depend from the main rafters. Excepting the lower part of the walls, the Norman hall of William Rufus was re-built three centuries afterwards by Richard the Second, who, on its completion, in the year 1399, solemnised Christmas by a characteristically splendid feast; and every lineament of the roof, so far from partaking of the Norman manner, proclaims its origin to have been late in the fourteenth century.



The error in thus following Dr. Robison might alone warrant a doubt whether the concealments of which the writer who quotes him speaks actually exist, and whether his assertion, that "con-

structive principles, if true, must be anti-Gothic; that to make open roofs beautiful and truthful, all Gothic ideas must be relinquished, &c.," have received from himself the reflection befitting their unqualified expression. With respect to the remaining portions of the critique alluded to, I may say, with the editor of the journal in which it appeared, "that his arguments have not convinced ourselves;" and then I will proceed to bring under notice that key to the construction of this truly wonderful example of carpentry which I ventured to advert to in this Institute six years ago. It was, however, mentioned as one among a series, and the prominence that will be imparted to it by thus receiving your attention in a detached form will, no doubt, secure the removal of any error it may contain, and the candid admission of any merit it may possess.

My observations went to show that the arch was not merely a very grand ornamental feature, but that it was absolutely the essential principle and weight-sustaining medium of the truss; and should this hypothesis prove correct, the propriety of the Gothic, or the compressible system of design in carpentry must, I conceive, be admitted.

Commencing, then, with the great arch rib, which in its section is upwards of two feet each way, and spans the width of the hall, we find, that dividing the curve from the springing to the apex into three parts, the first of such divisions gives a point in the rib at which it is intersected by a massive horizontal beam of nearly equal dimensions with itself. This horizontal timber. called the hammer beam, extends outwards to the foot of the rafter, and is continued in the opposite or inward direction to the same extent, so that if secured on a central pivot, this timber might be acted upon as a scale-beam or lever of the first order, and if loaded equally at both ends would remain in its horizontal position, while the entire weight would be concentrated at the pivot and thrown upon the supporting arch. If, taking the hammer beam as a base, we draw a perpendicular line from the inner extremity, it will be found to cut the rafter, or surface of the roof, just midway between the foot and the ridge, and taking this rafter or surface line as the hypotenuse, a triangle will be completed.

This triangle will be found to have an exact counterpart in the upper half of the roof; but as the weight is proportionate to the superficial area, it is only necessary to explain that this area is divided longitudinally into two equal parts that under this divisional line a purlin exists, upon which is collected the weight of the upper half of the roof, and this weight is transmitted, by a vertical post, to the inner end of the hammer beam. The lower half of the roof discharges, in like manner, its weight on the outer end of the same timber, and the equipoise is thus rendered perfect.

If the accuracy of this much be conceded, I think but little remains for discussion. The fitness of the skeleton for its intended purpose once seen and admitted—the graceful adaptation of the tracery, and minor arrangements for supporting the slighter parts by aid from the stronger will be manifest, and especially so when it is recollected that gravitation is not the only force to be resisted, but that the powerful action of the wind, on so large a plane, has also to be largely provided against. In tracing the history of these roofs, I have formed the opinion that their type is found in the stone gablets, or principals, employed in early halls, of which Conway Castle affords good examples, and a specimen also exists in the Manor House at Ightham, in Kent.

Professor Willis has remarked—"A small chapel at Capo di Bove, about a mile outside Porta S. Sebastiano, Rome, figured by Agincourt, has the roof entirely sustained by a series of pointed arches, resting on corbels, and entirely superseding the usual trusses." I have not met with this illustration, but by the kindness of Mr. Railton, I can supply its place by the drawing of a chancel, in which he has carried the principle into effect. The more ancient employment of such gablets may be further referred to in the aisles of Hartlepool Church, Durham, where they exist in a perfect state; and of St. Peter's, Northampton, where the remaining portions clearly indicated (at the time of my visit a few years since) their original use. The nave of St. Peter's Church, I am inclined to think, had its roof supported by a series of such gablets, above the alternate piers. The Church of San Miniato, without the walls of Florence, has precisely this arrangement, except that the gablet occurs over every third pier only; but in other respects the quatrefoil plan of the pier, and the appropriation of two of the group of shafts to the support of the nave arches (one at the back for the gablet across the aisle, and the fourth in the front, which is carried up on the face of the clerestory, for supporting the arch and gable over the nave) are identical in the two churches.

Speaking of San Miniato, Mr. Galley Knight observes—"Large arches are thrown at intervals over the nave, connected with smaller arches, which are thrown over the aisles, at once assisting to support the roof, banding the whole fabric together, and giving it additional strength. When these arches occur, the pillars are exchanged for compound piers, one shaft of which is carried up to meet the arch above."

At San Zeno, Verona (a Romanesque edifice, begun in 1138, and finished in 1178) every alternate pier is a massive collection of shafts, with arches crossing the aisles and nave, as in the above instances. So striking indeed is the resemblance in these buildings to many of our own Norman churches, where we find shafts carried up with no reference to the present roofs, and yet well adapted to the support of such gablets as I have been describing, that there seems good reason to conclude that such features were at one time very general in this country, as well as abroad, and the question addresses itself to the attention of those entrusted with the restoration of our more ancient churches.

Previous to the date of the Westminster roof, timber arches had been applied in a form consonant to the general characteristics of their date, as at Nursted Court, near Gravesend, and other places; whether the hall of Rufus was entirely covered by wooden framing, or had stone supports, the construction in wood of such a gablet as we have been considering, was the task proposed to himself, and, in my humble opinion, nobly performed by the architect of Richard the Second. Of those indeed who, to prove the falsity of its principle, refer to the distortion it has sustained in four centuries-and-a-half, it may be fairly inquired, whether the many failures in masonry warrant the denial of truth in the theory of the arch altogether. The term "foliated" has been ably advocated as applicable to the later wooden roofs, but in examples antecedent to the introduction of foliations as a common architectural feature, the roofs were, of course, without that characteristic; and in modern works where cusps are excluded, as in lancet buildings, they are, I presume, still generally and properly omitted. Such unfoliated roofs "possess," it has been said, "the merit of giving a grand and church-like, though simple effect, without doing violence to the genius of its material." They certainly embody, in an eminent degree, the principle of rendering elegant the essential constructive elements, and of avoiding adventitious parts for ornament alone.

In concluding these remarks, I will advert for a moment only to the unfairness and futility of instituting comparisons between open wooden roofs and stone groinings, unless they were equally suited to our means, and depended for adoption entirely on choice. I am far from insensible to the charm of "the fretted vault," but where is an example as capacious as Westminster Hall, doubling, as it does, the breadth of our widest cathedral nave? When wood, applied to the purpose of groining, is painted, and made to represent stone, a deception is clearly practised; but, regarding the arched ramifications of a natural grove as the type followed in ribbed vaultings, there would seem little impropriety in representing the "fair branches and shadowy shroud" of the cedar fairly and ostensibly in timber. The subterfuges witnessed in the wooden groining over parts of St. Alban's Abbey, York Minster, and other buildings, are, doubtless, owing to the ponderosity of stone. The sacrifice of internal height, which many of our finest edifices have sustained from the introduction of stone groining (and which would be quite destructive of effect in buildings of wide proportion), lays them open to the severe remark upon the splendid outer dome of St. Paul's, of being "a mere imposing show, constructed at a vast expense, without any legitimate reason;" for it need not be mentioned, that the groined ceiling never supersedes the ordinary roof, and between the two there often exists a chamber of considerable height, not only for the purpose of increasing the weight of the walls, and their ability to resist the thrust of the groin, but also to admit of building the latter under cover. The cost of the centring alone for a stone ceiling would, probably, pay for the decoration of an open roof; and the value of fair groining, if taken at fifty pounds a square, which experience enables me to state as a proximate sum, would place it quite beyond general application. While economy therefore confines us almost exclusively to the open form of roof, it is gratifying to experience the conviction, that it is truthful in principle, and, when artistically treated, capable of displaying, in the fullest and most graceful manner, the entire capacity of the building it covers.

Remarks.—Mr. DONALDSON thought that Mr. Morris had confined his remarks somewhat too exclusively to the peculiarities of construction in the roof of Westminster Hall. He had not, in

his opinion, sufficiently alluded to the numerous other examples of a similar kind existing in this country. It should be borne in mind, that in the roof of Westminster School, of which a drawing was exhibited, it had been found necessary to introduce cross tie-rods to connect the opposite hammer beams. It was a remarkable fact, that the flying buttresses of Westminster Hall are not placed exactly opposite the principals of the roof, and that a straight joint is to be seen between them and the wall: this would tend to prove that the stability of the roof is not dependent on them, and that they had been probably added at a late period, when the walls had evinced signs of weakness.

Mr. Morris replied, that the object of his paper had been to show that the arch-ribs of Westminster Hall are not mere ornamental portions of the structure, but that the weight of either side of the roof is brought to bear upon two of the strongest points of each rib. At Eltham the same principle was carried out, some eighty years later than in the present case.

Mr. T. T. Bury (Fellow), mentioned, that in the clerestory roof of St. Mary's, at Bury St. Edmund's, the hammer-beam construction is introduced alternately with the single arch-rib, and produces a varied and good effect.

Mr. Bellamy (Fellow), thought that no one could look at the roof of Westminster Hall without feeling assured of its stability; and he was astonished, that after it had stood the test of time during four centuries-and-a-half, any one should venture, not only to decry its beauty, but actually to call in question its principles of construction.

Mr. C. H. Smith stated, that upon a close inspection of this roof, he had ascertained that the foot of the arch-rib did not rest upon the projecting portion of the moulded stone corbel, but that an actual space existed between them; and he had been informed by a competent authority, that this is the case with many similar roofs.

Mr. Fowler, V.P., said, that he also had an opportunity of closely inspecting the construction of the roof of Westminster Hall at the time of the erection of the lantern, and of the general repair some thirty years ago, and he had observed the expedients adopted to secure the roof, by means of bolts and ties, which compensated for the decay of the pins and tenons of the framing, but were not required from any defect in the principles of the construction. With respect to the paper which had been read, he gave the author great credit for his ingenious explanation of the principle on which this roof was constructed—viz., that of equi-poising different portions, and eventually bringing their whole weight to bear upon the points best adapted to receive it. Mr. Smith's observations respecting the corbels did not, in his opinion, tend to disprove the theory advanced by Mr. Morris, but rather showed the prudence of those who constructed the roof; it would certainly have been very injudicious to allow the feet of the ribs to impinge upon the extreme ends of the corbels, weakened as they were, to some extent, by the mouldings. The ribs were, doubtless, continued into the solid of the wall. He was glad to see that this mode of construction was not only admired, but had actually been carried out in some of our modern buildings.

Mr. Tite (Fellow), thought that all the theoretical objections to the principle of construction of such roofs as Westminster Hall were most satisfactorily answered, by the mere fact of their having stood the test of centuries; and he thought we might be well satisfied, could we assure ourselves that the roofs erected in our time would be in as good a state of preservation 450 years hence as that now covering Westminster Hall. He also observed, that all tie-beam roofs are liable to objection, on account of the shrinking and deflection of the timbers.

Mr. Penrose (Fellow), thought that the arched form of the rib had more to do with the appearance than with the stability of the roof. He remarked, that in the roof of Westminster Hall timbers acting as struts had been introduced between the main ribs and the principal rafters; and he was inclined to consider that the real advantage of the ribs consisted in their acting also as struts, and, at the same time, binding the whole frame-work together. It should be remembered that there were many roofs formed on the tie-beam principle, which were well worthy of commendation—as, for instance, that of St. Nicholas, at Lynn, in Norfolk, and many others in Somersetshire; and it must not be forgotten, that these roofs can be executed at a far less outlay than those constructed on the arch principle.

Mr. G. G. Scott (Fellow), considered that the curved, or arched rib, was not useless. Its object was not so much to bear any portion of the weight of the roof as to prevent it spreading outwards. This was done also, to some extent, at King's College. In a roof of 68 feet span, without a tie-beam, like that of Westminster Hall, we had no right to complain of the existence of buttresses; but, in his opinion, they were used rather as a precaution, than from necessity. It must be remembered that the walls were 300 years older than the roof; and it was very probable that the buttresses were erected with the view of counterbalancing any weakness that might have been produced by such a lapse of time. Had the walls been new, buttresses, in such an erection, could not be condemned.

The Chairman thought it was worthy of remark, that the buttresses are so constructed as not to give their resistance at the point where the greatest lateral thrust is exerted—viz., at the level of the stone corbels.

Mr. G. G. Scott drew attention to the roof of a remarkable ruin at Mayford, in Sussex, which was of 40 feet span, and had stone principals, or gablets; the walls were of moderate thickness; and, although the hall had been in ruins 300 years, these stone principals were quite sound.

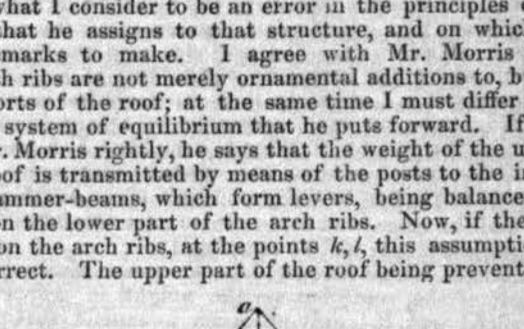
The Chairman.—The roof was counterbalanced by buttresses.

Mr. Scott.—Yes; but the buttresses are in ruins, while the arches or principals are yet sound.

The vote of thanks to Mr. Morris was then put and carried.

TO THE EDITOR OF THE C.E. AND A. JOURNAL.

Sir—In the paper read by Mr. Morris at the Institute, on the structural principles of the Roof of Westminster Hall, I have noticed what I consider to be an error in the principles of equilibration that he assigns to that structure, and on which I have a few remarks to make. I agree with Mr. Morris that the great arch ribs are not merely ornamental additions to, but principal supports of the roof; at the same time I must differ from him as to the system of equilibrium that he puts forward. If I understand Mr. Morris rightly, he says that the weight of the upper part of the roof is transmitted by means of the posts to the inner ends of the hammer-beams, which form levers, being balanced at their centres on the lower part of the arch ribs. Now, if the posts do not rest on the arch ribs, at the points k, l, this assumption is perfectly correct. The upper part of the roof being prevented by the



collar-beam from spreading, may be considered as resting on the inner ends of the hammer-beams, by means of the posts d, f, e, g, and pressing vertically with half its weight on each. Mr. Morris then says: "The lower half of the roof discharges in like manner its weight on the outer end of the same timber, and the equipoise is thus rendered perfect." Now, to this I demur. The weight of the lower part of the roof d, b, f, will act vertically, not at the outer end b, of the hammer-beam, but in the vertical line drawn through its own centre of gravity; and if the great arch rib intersect the centre of the hammer-beam, then at the point of intersection. (This is speaking of the roof *covering* only, without reference to the weight of the frame; if this be considered as well, the vertical action of the lower half of the roof d, b, f, will be inside the point h, in consequence of the greater weight of the post d, f, and the framing on that side of the point.) The lower portions of the roof d, b, f, e, g, c, will then each be in equilibrio, or will balance themselves on the points h, i, of the great arch rib: this, I think, is plainly evident on inspecting the diagram. The frame b, d, f, with its proportional weights of covering, would plainly not keep itself in equilibrio if the point h, were nearer the wall, but would undoubtedly turn over on this point, and fall inwards. It is therefore impossible that the lower portions of the roof, only keeping themselves in equilibrio, can also balance the additional

weight of the upper portion of the roof resting on the posts at the points *d*, *e*. It is consequently manifest that there will be a very considerable vertical pressure on the posts *d*, *f*, *e*, *g*, unsupported by any counterpoise at the outer ends of the hammer-beams, and tending to upset the frames *d*, *b*, *f*, *e*, *g*, *c*, inwards, by turning them on the points *h*, *i*, as centres; and this would undoubtedly be the result, unless this force were otherwise counteracted. Now, this pressure, I conceive, is carried by the great arch rib at the points *k*, *l*, where the posts intersect it; and it thus affords five principal points of support to the weight of the roof—one at the centre of each hammer-beam, one at each post, and one at its apex *m*, at the collar-beam under the king post, which I conclude in this case fulfils the duty, not of a suspending tie, but really of a post. The lower arches of foliation will also assist in sustaining this weight. The pressure thus thrown on the arch ribs is discharged at their feet on the wall; and their rise being so high in proportion to their span, they probably exert a comparatively small side pressure against the wall. On the supposition of the upper part of the arch rib not receiving the pressure of the posts *d*, *k*, *e*, *l*, this pressure would of course be transmitted to the inner ends of the hammer-beams. We should then have it acting vertically, and resolving itself into a horizontal compressing force against the collar-beam at the points *d*, *e*, and an oblique force against the points *h*, *i*, of the arch ribs. In this case the direction of this pressure will be very nearly a tangent to the rib at the points *h*, *i*, and will be transmitted by the arch rib to the wall. As the wall is of considerable thickness, the direction of this pressure probably does not pass outside, but reaches the foundation within the thickness of the wall. The wall has also the weight of its upper portion above the springing of the ribs to assist it. The oblique pressure at *h*, *i*, certainly tends to force the arch ribs outwards, turning them on their springing as centres; but against this is opposed the weight of the rib itself, and also that of the arch of foliation, which acts in the opposite direction.—Offering these remarks to your notice, if you think them worth a place in your journal,

I am, &c.,

July 11*th*, 1850. J. A. DAVIES.

LIGHTHOUSE IN THE SKERKI CHANNEL.

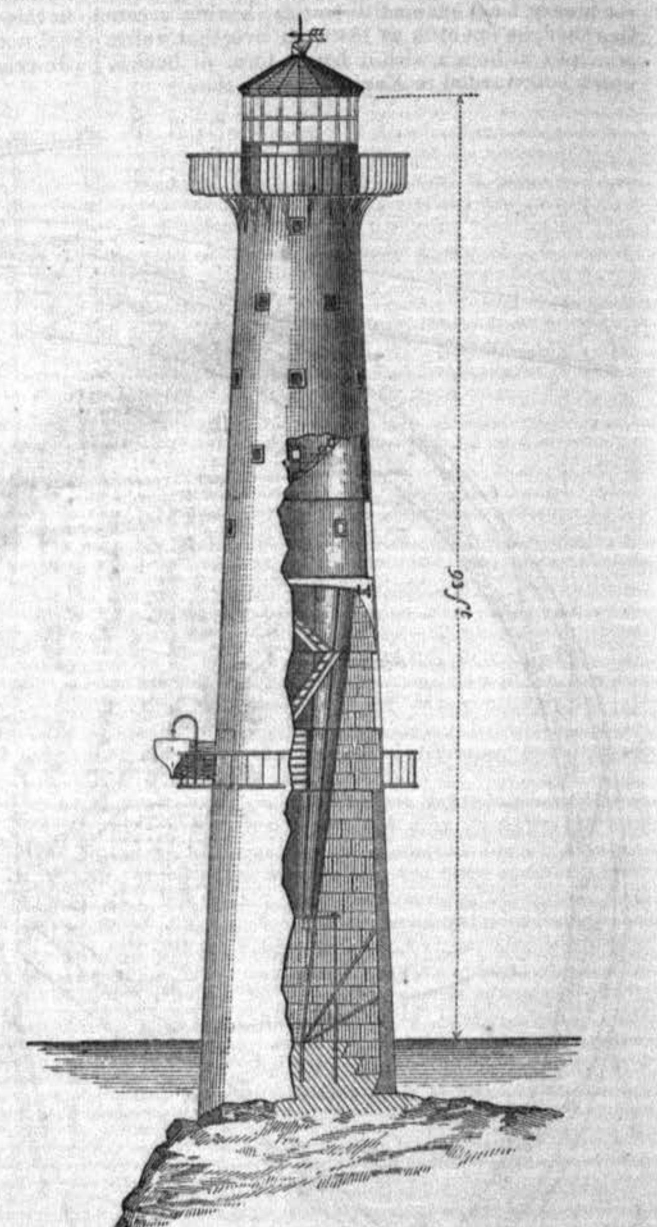
WE extract the following description from a very able report by Mr. Alexander Gordon:—

"Admiral Sir Francis Beaufort suggested to me the importance of a lighthouse in the Skerki Channel, for Keith's Reef. I am now able to assert confidently, that a lighthouse can be erected on Keith's Reef, showing a light of the greatest power 100 feet or more above the sea, capable of containing stores, provisions, and water for four men, or even more, for six months, and at an expense not exceeding 17,000*l*. The rocks are compact limestone, in extent nearly half-a-mile long, and one-third of a mile broad, with a small space of about six feet square, even with the water's edge.

"The sketch is partly an elevation and partly a section of such a lighthouse as I would propose for Keith's Reef, to show a light of the most powerful character at the height of 93 feet above the water level, and the tower sufficiently spacious to contain even six men (if such should be required by stress of weather) for six months, and all necessary lighthouse stores, provisions, and water, with ample space for exercise, and for live stock.

"A strong wrought-iron bar should be at once jumped into the centre of the area of the peak, and immediately succeeded by other wrought-iron bars, on which to form a crow's nest, or an open platform; from this the surface and edges of the rock could be cleaned of the large quantity of sea-weed now upon it, and a small crane would enable us to have the edges of this rock trimmed and undercut, and a circular seat rudely prepared about six feet under water. It may not, however, be necessary to go to such a depth. A few sections of this seat will enable us to cast lead slabs weighing a ton and a-half or two tons, such as can be dovetailed into each other, and fastened together with lead joggles and dowels driven in hard, and the whole of the seams closely chinced or caulked with lead. This wall of lead will then be carried up about 15 inches thick, with the seams all chinced together below and above the water line, so as to prevent percolation of water. This lead wall, where above water, will have its seams all run together with a powerful blow-pipe. We may even manage to cast the upper portion of the lead wall upon the lower part.

"The original iron rods will now be at their upper ends worked into the inner and dry side of the lead wall, forming bond as we proceed. At the extreme base of the tower the water will now be shut out by warm gutta percha, and then by hydraulic cement. Lead will then be run in to make the base perfect; a core of masonry perfectly bonded together is to occupy a great part of the interior. The fixed crane post may then be built in, and thus be converted into bond and load; even if it should in some degree oxidise, the rust will do good rather than harm.



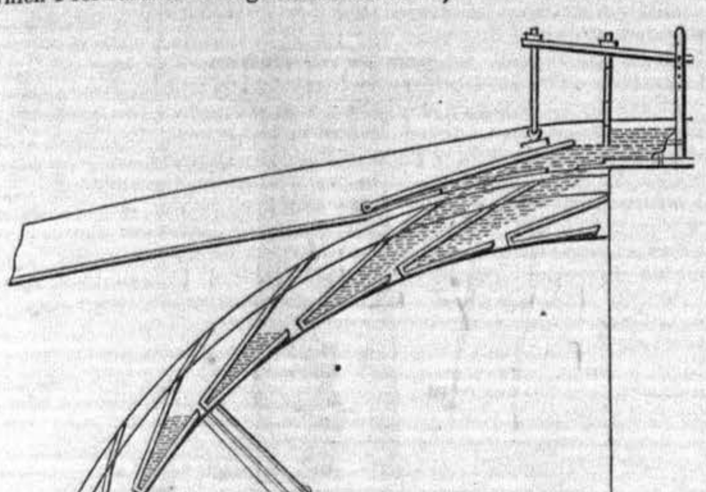
"Lead is no doubt a costly article as estimated below, but its durability in salt water; the facilities which it affords for making perfect bond; its inertia; and its not being susceptible of vibration, point it out as the best material under the circumstances.

"The lead walls are to be carried up about 24 feet above the water-line, and upon them and the core of masonry (the latter in many places bonded together with lead), there will be a superstructure of cast-iron bonded together with wrought-iron floors and fastened down to the rock by many very strong wrought-iron ties; which latter will not (where there is moisture) be allowed to come in contact with the lead. The junction of the iron shell and the lead wall must have special attention. In the event of oxidation of the iron to any considerable extent, such plates can be removed; and if the oxidation be small, we can repair the damage by scraping away the oxidised iron and running in more lead in its place. The superstructure would be much the same as that of my other lighthouses. Its cost may be estimated at 17,000*l*.

"ALEXANDER GORDON."

OVERSHOT WATER-WHEEL.

SIR—A reader and admirer of your excellent *Journal*, I have lately perused with interest a paper reported in your August number, for last year, read by Mr. Fairbairn, at a meeting of the "Institution of Civil Engineers," upon the subject of "Ventilating Water-Wheels." To the value of this improvement in hydraulic machinery I am enabled to testify, having erected, in this neighbourhood, as far back as 1843, an overshot water-wheel upon that principle, although with different form of bucket (a description of which I forwarded to England at the time.)



My immediate object in troubling you with the following remarks is chiefly in reference to an observation of Mr. Fairbairn's, which appears to me to require explanation; to the effect, "that the principle of ventilated water-wheels is not so essential to *high falls, being more expensive.*" I beg leave to submit the enclosed diagram, which will testify that it is *possible* to avoid the objection of *expense* in such wheels—the cost of such as this certainly not *exceeding* that of the *most simple* of the usual forms of bucket. As regards "high falls," it might be remarked (were it not admitted as an axiom), that such is even the most economical mode of application if the power is "*on the level;*" and, as it cannot but be admitted that the other advantages of the principle are applicable to the overshot wheel (the same necessity existing in these, as in others, "to carry down the water as nearly as possible to the vertical centre, and there allow it to escape with facility"), its application to this description of wheel is equally important, especially where economy of motive power is an object.

The above objects are obtained to a very considerable extent by the angle, and form of bucket, and mode of ventilation, as shown in the diagram. An overshot wheel, 26 feet diameter, has been in successful operation since 1843, realising a great economy of power, with increased effect.

My immediate object at the time of erection was to economise power—the old wheel requiring an accumulation of water during eight hours of the twenty-four. After much consideration, however, of the various improvements which suggested themselves upon Smeaton's form and make of bucket, I determined to *prove*, by confining myself strictly in the new, to the dimensions and materials of the old wheel—I should say, as to diameter of wheel, number and width of buckets, and depth of shrouding; strengthening the arms, however, with right-angular flanges, to obtain "stiffness." At work, the wheel perfectly answered my expectations, the stream being more than sufficient to work the wheel without accumulation, and more efficiently; proving the value of the principle *applied to overshot wheels*—at least, with proper form of bucket.

The form used being quite different to any hitherto adopted—simple and effective, and applicable also to breast wheels, the mode of obtaining it may not, perhaps, be without interest. It is formed by a right angle drawn from the vertical radius, at the inner circumference of the shrouding (at foot of wheel); continued at a slightly decreased angle through the outer division of the shrouding (for the purpose of assisting the retention of the water to the lowest point). The sole of the bucket is formed by the next following radius, intersecting the line or tangent; and the inner line, by the sheathing of the wheel, as high up as the openings left for the exit and admission of atmospheric air; the angle of this being slightly altered from the "circle" to facilitate the passage of air, by its collision with the sole of the advancing bucket.

I adopted the above angle and form of bucket as best adapted to *support and retain the water to the lowest possible level;* and by admitting air to the buckets, my object was not only to effect a rapid discharge of water at that point, but also to facilitate its admission to the buckets at the head of the wheel; not only to insure economy of water, by preventing loss by splashing, but to obtain the greatest possible *effective power*, by *retaining* the water in the wheel.

It might be supposed that an escape, or loss of water, would take place through the openings of the upper buckets; this, however, at a speed of five to six feet per second of the periphery, is not the case, the resistance of the air, whilst escaping through the openings, being sufficient to prevent leakage until the velocity of the wheel has carried round the bucket to a level sufficiently *low* to retain the charge of water. The conical form of bucket assists also the admission, as it facilitates the exit of the water; (the quantity of air admitted at that point is in proportion to the velocity of the wheel.) The wheel is, in fact, *perfectly water-tight*, as it *is released from backward pressure, and exceedingly retentive.* By these means I obtained

> Economy of motive power;
> Increase of working power;
> Freedom and regularity of motion;
> "Stiffness," or inflexibility of construction;
> *Without increase of Expense;*

Depth of shrouding should be avoided; extra power obtained by width (or breadth) of wheel.

I can conscientiously advocate the adoption of the principle of "Ventilation" to the "Overshot Wheel;" which application of the system does not appear to have been contemplated by Mr. Fairbairn, and to have been actually considered as *impracticable* by gentlemen present at the meeting.

I am, &c.,

THOS. B. DODGSON, *Manager.*

Ponta de Arca Ironworks and Dockyard,
Rio de Janeiro, May 1st, 1850.

CHEMICAL COMPOSITION OF WATER.

Professor Way, Consulting Chemist of the Royal Agricultural Society of England, delivered a lecture before the members, at their House, in Hanover-square, on Wednesday, the 19th of June, "*On Variations in the Chemical Composition of Water, as affecting its Agricultural Uses.*"

The Professor commenced his lecture by stating, that he intended on that occasion to call the attention of the members to three important heads of inquiry connected with water; more with a view to elicit from them practical illustrations founded on their individual experience, than to offer anything particularly novel or established. These heads of inquiry were the following, namely—1. On Water for Steam and other Boilers: the means of ascertaining its comparative suitableness for that purpose, and of counteracting its tendency to incrustation. 2. On Water for Irrigation: its chemical impregnation, and the theory of its action. 3. On the influence of Water, obtained under different circumstances, on the health of Cattle, Horses, and other live-stock on a farm. He remarked, that as the first head of inquiry related to the mechanical and chemical agency of inert matter, its details came within the range of analytical investigation; and he would be enabled to speak with much confidence on the facts he had to bring together under it; but as the other two heads included a reference to local circumstances, and to the influence of the vital operations of vegetation and animal physiology respectively, in the production of results, what he had to say on these points would be much less decisive, and advanced more for the purpose of seeking than for giving information.

I. *Water for Boilers.*—The water from the clouds reaches the earth almost pure in a chemical sense, as a homogeneous liquid, composed of the elements oxygen and hydrogen. It was distilled from the sea and land, and from the leaves of vegetables in a state of purity, and formed clouds; from which it again fell at intervals to the earth through the atmosphere, bringing with it only very minute traces, varying according to circumstances, and frequently inappreciable by the chemist, of carbonic acid gas, ammonia, nitric acid, and the effluvia arising from animal perspiration and the decomposition of animal matter. On reaching the land, however, its solvent power immediately came into operation, and it became impregnated more or less with the soluble substances with which it came in contact; common salt and gypsum were always dissolved by it, while lime and other substances were taken up by it when there happened to be an excess of carbonic acid gas present. In order to illustrate this fact, the Professor exhibited to the members a simple and striking experiment. Three glass vessels were connected together by means of bent glass tubes; the first vessel contained fragments of marble (as a pure variety of native carbonate of lime); the second, distilled water; and the third and last, a clear solution of quick lime in pure water (or lime-water.) On adding dilute muriatic acid gradually to the marble in the first vessel, carbonic acid gas was disengaged in great abundance, which passing along the tubing into the middle vessel, was there washed and freed from impurity by its passage through the distilled water, and then proceeded, by means of a connecting glass tube, to the lower part of the inner surface, where it continued to bubble throughout the clear lime-water. After a few moments the lime-water became turbid. The Professor remarked, that this effect resulted from the conversion of the lime into insoluble carbonate of lime (or chalk), by its combination with a first proportion of the carbonic acid gas passed through it. In a few moments afterwards, however, the liquid regained its original transparent appearance. This change, he explained, arose from the further supply of the same acid gas, constituting the insoluble carbonate of lime a soluble super-carbonate of that earth; the liquid, in fact, being then a solution, not of lime in water, as it was originally, but a solution of bi-carbonate of lime, or of chalk rendered soluble by excess of carbonic acid. To prove that this was the case, the Professor took the flask containing this solution, and having placed it over a spirit-lamp, caused ebullition to take place. After boiling for a short time, the liquid again became turbid, from the circumstance of the heat expelling the excess of carbonic acid, and again reducing the carbonate of lime to the state of insoluble chalk. He then proceeded to show how this experiment illustrated the change which was found to take place in the waters of limestone districts, which were naturally charged with carbonate as well as the sulphate of lime; and also how it happened that, while water, rendered hard by sulphate of lime only, did no injury to steam-boilers, as that salt was not deposited on raising the water to a boiling temperature; hard water, on the contrary, holding a large amount of carbonate of lime dissolved in it by carbonic acid, did the greatest injury to them, by gradually depositing, on being boiled, such carbonate of lime at the bottom of the steam-boilers, until it amounted to a hard calcareous incrustation.

Hard Water.—Water was always rendered hard by holding in solution either the carbonate or the sulphate of lime; and, accordingly, when obtained from wells in the chalk, oolitic, and limestone districts throughout the kingdom, was always hard; becoming turbid when boiled, and depositing its carbonate of lime on that part of the internal surface of the boiler nearest to the fire. As a familiar instance, he named the fur or crust in teakettles, in districts where such water was used; but in the case of steam-boilers, this deposit was one of the greatest evils that could be imagined. The hard calcareous incrustation in immediate contact with the iron plating of the boiler, amounting in a few weeks to no less than from two to three inches in thickness. Professor Way explained how the injury arose in this case—namely, from the effect which the adhering crust had in preventing the transmission of the heat, received by the boiler from the fire, to the body of water within the boiler. He cited many curious instances of the cooling effect of this free transmission of heat on substances under other circumstances most fragile and combustible; and the contrary effect when the transmission of such heat was obstructed, as in the case of calcareous incrustation, when the heat was arrested by the solid slow-conducting body, and the temperature raised above that of boiling water. He stated that, however odd it might sound to make the statement, it was no less true, that water might be boiled in an orange-peel, in an egg-shell, or in a vessel made of thin wood, or even of common writing paper; the heat applied to the external surface being rapidly transmitted to the water, and the heat carried off in the steam generated, while the material employed for the boiler suffered no injurious effect from such application of heat. He related a singular instance of this kind, in the case of a person at Liverpool, who had frequently had his cotton-mill burnt down. The party in question imagined, that if he had a large reservoir for water placed at the top of his factory, constructed of wood instead of metal, the wood, in case of fire, would be immediately burnt to ashes, and the water would consequently be set at liberty and extinguish the fire. The fire unfortunately did break out again, as it was feared it would, but the wood, instead of being charred or burnt, remained entire, and, being encircled by the flames, the water continued to boil in its wooden reservoir as long as any remained. The furring of a boiler preventing this transmission of heat, and thus causing injury to the substance of the boiler, was the reason why, in some districts, where the water was charged with bi-carbonate of lime, the boilers were found to wear out sooner than in others; and why the railway companies had been led either to seek for soft water, or to soften the hard water they had been in the habit of using, by the addition of some substance that would prevent its furring their boilers. The London and South-Western Railway Company had used the substance known in commerce as sal-ammoniac, with great success; by dissolving one ounce of it in 90 gallons of water, in tanks kept specially for the purpose. This substance was the neutral salt, so long familiar to chemists as the muriate of ammonia, being a compound of muriatic acid and ammonia. Its action in removing the hardness of water arising from bi-carbonate of lime was explained by Professor Way in the following manner. When muriate of ammonia and carbonate of lime are brought together in solution, a double decomposition ensues, each of the four combining substances changes its relative position, and two new salts are the result—namely, carbonate of ammonia, which is volatile, and accordingly makes its escape into the atmosphere; and muriate of lime, one of the most deliquescent salts with which chemists are acquainted, and which consequently remains in the water in a state of complete and almost permanent solubility. It might, he remarked, be said, that the ammonia of the sal-ammoniac carried off the carbonic acid, while the muriatic acid dissolved the lime, thus liberating the water from the chemical conditions under which its hardness was occasioned.

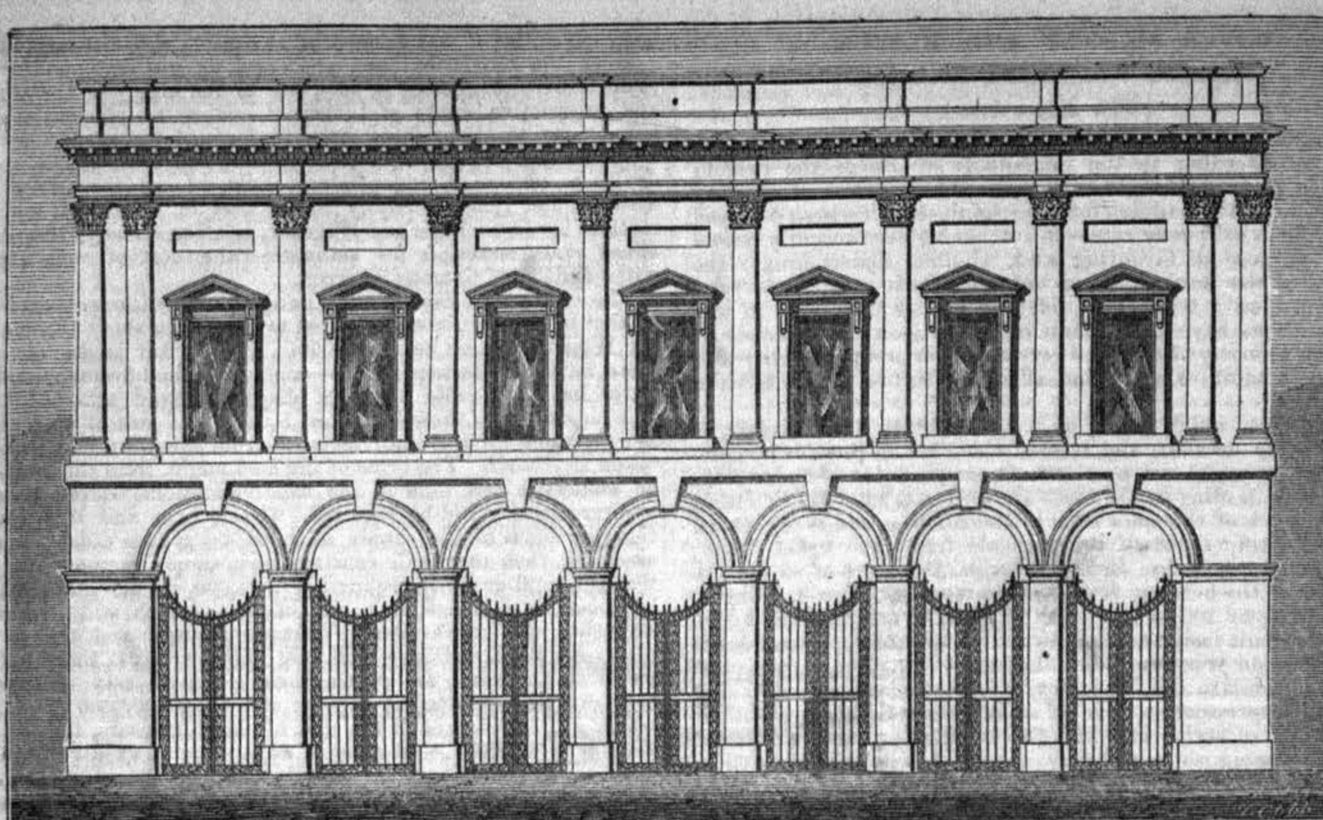
Softening Water.—Professor Clark, of the University of Aberdeen, had, however, proposed a plan for softening water rendered hard by carbonate of lime, which Professor Way considered much better than the one just described, and which might be adapted to the uses of agriculturists. This plan consisted in adding to such water a certain quantity of quick lime, which would unite with the excess of carbonic acid, and become converted into carbonate of lime, at the same time that it would reduce by such abstraction the bi-carbonate also to a state of carbonate, and both being insoluble,

they would, of course, fall as precipitates to the bottom of the vessel, or other enclosure in which the water was contained, leaving the water entirely free from the bi-carbonate of lime to which its hardness had in a great measure been owing. He then proceeded, to describe Professor Clark's system of soap-tests, for ascertaining the relative degrees of hardness possessed by certain waters. He remarked that hard water, as was well known, curdled soap, which would not produce a lather until such hardness had been overcome. Professor Clark had recommended a solution of white curd-soap in spirit of wine of a certain strength to be employed in this testing. This solution would at once produce a lather with soft water, but not with hard water until a certain quantity of the solution had been added to it for the purpose of counteracting the hardness: when lather of a proper firmness had been gained, the amount of standard solution employed to produce the effect indicated the degrees of hardness of any particular water; thus a standard of comparison was established, by which the choice as to different sources from which it would be most advantageous to procure water could be satisfactorily determined. Professor Way then performed an experiment with this soap-test, on spring-water from the chalk at Croydon, in comparison with water from the Thames; the former indicating a hardness of about 18°, and the latter of about 15°. The operation consisted simply in adding to the water, from a graduated pipette or suction tube, successive measures of the solution, until the water when shaken up maintained a lather on its surface for five minutes. The number of measures then indicated the quality of the water, two soap measures being equal to one degree of hardness. The process was described as easy, exact, and simple; and one which might be practised by any gentleman who was interested in such subjects, without spoiling either his furniture or carpets. It would also indicate the hardness resulting from the presence of sulphate of lime, as well as that from the bi-carbonate; though, as he had previously remarked, water hardened by sulphate of lime offered no objection for use in steam-boilers, as the sulphate by boiling did not become deposited, as was the case with the carbonate; in an economical and domestic sense, however, water rendered hard by either of those salts of lime was objectionable. Professor Way then observed, that Professor Clark, in recommending quick lime to soften water containing the bi-carbonate, advised such quantities of lime to be added as a preliminary trial by the soap-test process should indicate as being requisite. Such water would, by this process, be rendered soft for domestic purposes, and for steam and other boilers. The only difficulty consisted in tanks being required for the due subsidence of the chalk thus brought into an insoluble state in the water; but that was an obstacle which would no doubt be surmounted, when it was considered how great the benefit of this plan would be found, not only in ordinary families but in union-houses and prisons; that it was estimated that in London alone 600,000*l.* every year was expended in the purchase of soap, one-half of which was wasted in the hardness of the water; and how important a point it was in the processes of bleaching, dyeing, and other staple manufactures carried on at Bolton, Manchester, Bradford, and other places, to have a soft water in which lime was absent; it would, he thought, be well worth the while of all parties interested in so important a question to make arrangements for the depositing tanks required. The Professor concluded this part of his subject by throwing out hints by which soft water might perhaps be artificially obtained on a large scale, and at little cost, where it did not occur naturally. He remarked, that water was found by experience to become softened by passing through the soil; water, only, however, which was rendered hard by the bi-carbonate of lime. Thames water filtered through clay made permeable by the admixture of sand, was found to become as soft as by Professor Clark's process. Drainage water through regularly permeable stiff soils was more suitable for steam-engines than spring-water. But whether water thrown over the land would by that means become soft, he was not prepared to say. When, however, it was considered that one acre of land received every year on an average 500,000 gallons of pure rain-water, sufficient for the wants of 35 people during that period, it might be a question whether poor sandy land or bad moor land might not be covered with flat tiles for the purpose of collecting the rain-water, which might be conveyed in earthen pipes to the places required for its use. He merely offered this suggestion for the consideration of parties more conversant than himself with the practical bearings of such an undertaking.

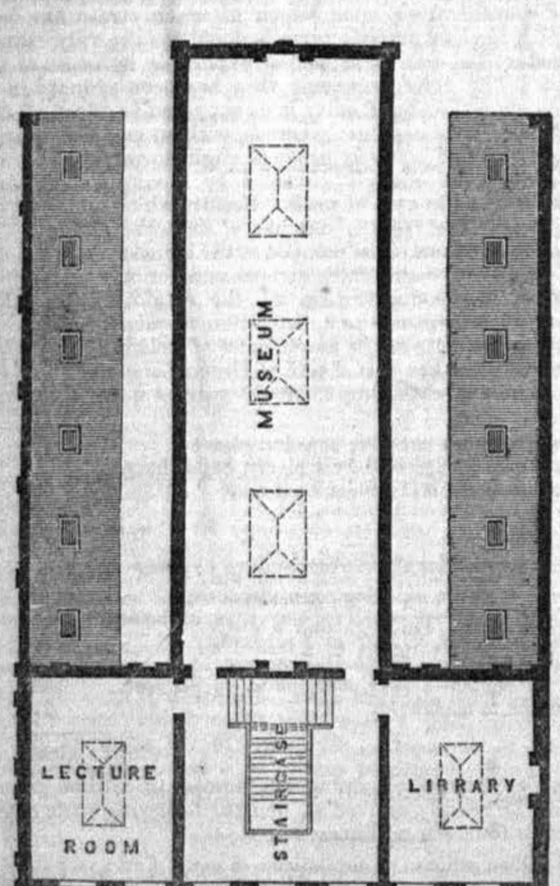
II. *Water for Irrigation.*—Professor Way remarked that, for the purpose of irrigating, he thought that water should be hard, and not soft as for other purposes: that it should contain the sulphates and carbonates of potash, soda, and magnesia, including organic matter, as all these were substances that would be taken up and retained by the land. If this view of the subject were the correct one, it would follow that the water in granite districts would, from its softer nature, not be so useful in irrigation as that in other districts where lime and other earthy substances were dissolved by the water passing through them. On a former occasion Sir John Johnstone had named to the council the failure of some irrigation of his from the supposed circumstance of the absence of mineral and earthy matter in the water, from the water in fact being too pure for the purpose. Sir John Johnstone being thus appealed to, replied that, in the water to which Professor Way had alluded, there was no trace of lime whatever. The irrigation had been laid out by the late Dr. W. Smith on a thin moorland sandstone rock; there was no lime whatever. Professor Way then proceeded to say that, in Derbyshire, and at Bala Lake, in Wales, the water was exceedingly soft and pure, but considered as unfit for irrigation. He felt no doubt that irrigation would become much more general than it had been; and the subject was more interesting at the present time on account of the Society's ensuing country meeting being about to be held in Devonshire, where irrigating operations had been so successfully carried out. He should, on that occasion, select specimens of the different waters, under different circumstances, for the purpose of analysis, in order that he might report, as requested by the chemical committee of the Society, the result of his inquiries on that interesting branch of his researches. It had been found, by ascertaining from analysis the nutriment required by the hop-plant, that only those soils that contained phosphate of lime and potash, would be suitable for the cultivation of that plant—such soils as those on the green sandstone of Sussex, Kent and Surrey; and that what theory had thus prescribed as the condition, practice had actually proved to be the most advantageous in fact, the cultivation of hops having been most successfully carried out on the soils in question. He thought it would also be found, analogically, that successful irrigation would probably be found to be confined to certain districts—namely, to the limestone principally. He thought it might be a question how far the influence of that operation was due to the temperature of the water, or its chemical composition, or to both; he himself considered the chemical nature of the water to be the most essential; at the same time, he was free to confess that we had all to learn upon this subject, and he trusted that an inspection of the Devonshire meadows would lead to further inquiries on the important questions connected with this subject.

III. *Water for Cattle.*—The Professor commenced this third head of his lecture by remarking that he believed it was a generally observed fact, that cattle liked the water of ponds, while they disliked that of limestone springs; that they preferred to quench their thirst in a green offensive collection of stagnant water, rather than in a running spring. In Bedfordshire he had seen cattle much relish a bad water filled with confervæ and animalculæ; which, however, was the only water to which they happened to have access. Farmers generally supposed that the cattle were fond of such water, on account of the green vegetable matter it contained; and a distinguished professor had explained the fact by supposing such water to be "meat and drink" for the cattle. It was certain they did not like hard water; and it gave a staring coat to horses when they were obliged to drink it; and when it was considered that water in chalk districts contained from 60 to 70 grains of carbonate of lime in the gallon, while London water (which was hard compared with others) contained only from 15 to 16 grains, it would be obvious how much difference would be found to exist in different waters. He regarded a good supply of water essential to health, and thought it a point of great importance to ascertain the kinds of water most suitable to the animal economy under different local circumstances. Professor Way concluded his lecture by expressing a hope that the members present would communicate to the meeting such cases of the practical effects of hard water on the health of cattle, as it had been his object, in the remarks he had then made, to elicit from them.

Filter for Sea Water.—M. Cardan lately described at the Academy of Sciences a new system of filtering intended to make sea water drinkable. The apparatus consists of a syphon, the long tube of which is filled with powdered charcoal. The author states that the sea-water after having traversed this syphon has lost its nauseous savour, and that the saline taste which remains is scarcely to be detected after it is mixed with wine. MM. Becquerel and Pouillet are named commissioners to examine into this communication, and we hope it will be tried at sea.

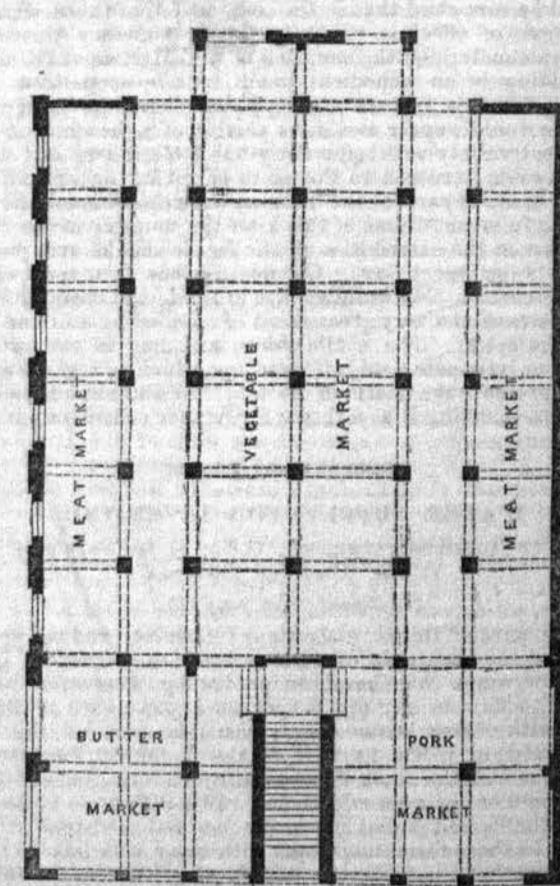


ELEVATION.



PLAN OF MUSEUM.

Scale 24 feet to 1 inch.



PLAN OF MARKET.

DOVER MUSEUM AND MARKET.

Edmund Woodthorpe, F.I.B.A., Architect.

DOVER MARKET AND MUSEUM.

EDMUND WOODTHORPE, Architect.

(With Engravings.)

THE building here represented has been lately erected for the purpose of affording to the inhabitants of Dover the twofold advantage of a market and museum. The expense of erecting that portion of the building forming the museum has been defrayed by means of a halfpenny rate—an act having been recently passed for the purpose of favouring such eligible undertakings; the expenses of the market being defrayed from a separate fund dependent upon a toll. The different parties interested in this laudable scheme have united their resources upon the principle of utilitarian economy: hence the very agreeable and profitable result of adding a most valuable and effective feature to the town of Dover.

The market, which serves as a basement to the museum, is surrounded by arcades, and is subdivided in the interior by cast-iron columns, which act as the main supports to the floor above. The staircase leading to the museum springs from a recess within the centre arch of the main front of the building, and is so planned as to completely separate the museum from the market below; The piers of the arches in the principal front are of stone; the remainder of the building is of brick, stuccoed. The building is 63 feet wide by 100 feet in depth; its cost in erecting was 4,000*l*. It has been built from the designs and under the superintendence of Mr. Edmund Woodthorpe, of London.

We congratulate the projectors of this scheme upon having selected so appropriate a style of architecture for their building; the pure Italian style—of which this building presents a graceful specimen—being so completely identified with the growth of intellect and the march of modern civilisation, is in the highest degree applicable to an edifice the chief purpose of which is so illustrative of the progress of learning and the development of taste which mark the present era.

It will be remarked that in the composition of this design, much playfulness of effect is produced by a judicious treatment of very simple materials; the coupling of the pilasters at the angles of the building is an expedient much to be commended in this instance: for this feature not only completes the design which otherwise would appear as a mere portion of a façade, but it produces great variety with apparently but little effort; and is moreover agreeable to reason on the score of giving an appearance of strength to those parts of the building where additional strength is required. In compositions of this kind the coupling of the columns or pilasters at the extremities of the façade should ever be considered as a stringent law. Considering the two very different objects for which this building was erected, the composition as a whole possesses the very great merit of displaying a fit and appropriate character. The establishing museums in our provincial towns is an interesting subject; and one which as regards our own country presents the charm of novelty. We therefore feel much pleasure in selecting it as a theme for further consideration.

WATER SUPPLY FOR LIVERPOOL.

REPORT OF ROBERT STEPHENSON, C.E., *on the Supply of Water to the Town of Liverpool.*

(Continued from page 235.)

IN the outset of this investigation, I certainly was not prepared to find that the multitude of fissures would not enable a greater quantity of water than has been proved by observation and experiment to flow to any given spot, as I was aware of the great facility with which water passes through some of the highly fissured primary rocks, as well as the mountain limestone and some portions of the chalk formation, which sometimes give birth at one point to considerable rivers. The difference is doubtless owing to the fissures being less in the new red sandstone at Liverpool than in those formations, and with such a variety of results, it is evident that experiment in each locality becomes the only true guide to the determination of the actual resistance offered by any particular formation to the free passage of water. The trials now brought together, which have been made in and near Liverpool, would appear to show distinctly that a larger supply, from one point, than about 1,000,000 gallons a day cannot be safely calculated on; and several distinguished scientific men and engineers concur in this opinion. It also appears that the wells, to yield large quantities of water, must be at considerable distances apart.

With the conviction thus impressed on me that none of the plans hitherto suggested is adequate to the supply of the present and prospective wants of Liverpool, and, as no efficient scheme has, to my thinking, been brought forward for rendering fully available the supply of water in the sandstone, I venture to devise a system of independent wells, placed throughout the district, and lying generally to the east of Liverpool; and the stations at Green Lane and Windsor, so often already referred to, afford again materials for estimating the cost of such a plan, without liability to material error.

The cost of the Green Lane pumping establishment, exclusive of that of mains, is already stated to have been about 19,000*l*. and the Windsor station nearly 30,000*l*. The former is scarcely complete, having no cottages for the engine-men and firemen; and the latter has a valuable parcel of disposable land attached to it. But judging from these instances, I think the cost of each of the new stations at a greater distance from the town may be fairly taken at 20,000*l*. The price of the land might, from the localities, be somewhat less than at the existing stations, while engines of greater power would be required. Green Lane and Windsor are together equal to the supply of 2,000,000 gallons a-day; so that, assuming that they will continue this supply permanently, and that the total quantity required is 8,000,000, six new stations must be constructed, which, at a cost of 20,000*l*. each, will amount to 120,000*l*.; and as the mains connecting them and the storage reservoirs at Kensington will cost about 48,000*l*., there will be (with 10 per cent. for contingencies) a total cost of 185,000*l*. requisite for the present supply; and for 11,000,000 of gallons, which will be required at the end of about 10 years, the cost will amount to 277,000*l*.,—an amount apparently in excess of the calculations already given, but in fact quite consistent, as the relation between the cost and supply cannot remain the same for quantities from different distances.

The first objection which will perhaps be made to this plan is, the want of concentration, upon which so much stress has been laid, and which in some manufactures is doubtless the very essence of cheap production; but it is not so applicable in a case of the present kind. The chief argument that has been adduced in its support rests upon the opportunity it is supposed to afford of dispensing with duplicate engines; whereas, with so many constantly at work, the failure of one will produce slight inconvenience, and the objection may be entirely obviated, by having an additional station, to be worked in case of need. Besides which, in supplying a town varying in level from a number of detached pumping stations, the water need not all be pumped to the highest reservoir, and the saving of power would fully compensate for any advantages derivable from the concentration of the establishment, while economy would result from the substitution of mains for tunnels.

The following estimate of the annual cost of working this system of wells is based upon the actual cost of Green Lane and Windsor, where the expense of obtaining 1,000,000 gallons a-day from each is:—

For current expenses including superintendence ..	£1100
Depreciation upon engines and machinery, engine-houses, and cooling-pond, £11,200 at 2 per cent.	224
Total	£1324

And at each new station the corresponding expense will be—

For current expenses, including superintendence ..	£1100
Depreciation upon engines and machinery, engine-houses, and cooling-ponds, £12,000 at 2 per cent.	240
Depreciation of mains, £8000 at ¼ per cent.	20
Interest on capital—namely, £30,800 at 4½ per cent..	1386
Compensation to landowners	250
Total	£2996

The annual expense of obtaining any number of million gallons a-day can now be readily arrived at, and the following table shows it from eight to fourteen millions:—

To obtain	8 million gallons.		2 old stations—		6 new.	Cost a year	£20,624
..	9	..	2	..	7	..	23,620
..	10	..	2	..	8	..	26,616
..	11	..	2	..	9	..	29,612
..	12	..	2	..	10	..	32,608
..	13	..	2	..	11	..	35,604
..	14	..	2	..	12	..	38,600

These calculations, if not exact, are certainly such approximations as will justify their application in a comparison with other

projects; and, in concluding my remarks upon this proposal, I am not insensible to one or two grave objections which may be made to it; but after much deliberation I am persuaded that distributing the establishment over a wide area of country is the only sure method of obtaining the requisite supply of water.

The length of connecting mains is the first obvious objection, but they would be less costly than the amount of tunnelling necessary for connecting works even much less widely spread. Another objection is the payment of a royalty to landowners for the abstraction of water, of which I am unable to form any very accurate estimate, but do not think that the amount now paid to the Earl of Derby at Bootle ought to be taken as a basis for calculation. The remaining objection which is urged against a divided establishment consists in the necessity for some additional superintendence, but this is too trivial to operate while the present necessity for a supply of water exists, which I am convinced can only be adequately derived from the sandstone by such means.

Mr. Hawksley's Proposed Supply from Rivington.

The third question submitted is—

"*Whether such supply can be obtained by means of the Rivington Works, and the cost of obtaining and distributing the same as recommended by Mr. Hawksley?*

In order to become thoroughly familiar with all the details of this undertaking, I first visited the locality, accompanied by its projector, for the purpose of receiving his explanations personally on the spot, and to satisfy myself by actual inspection of the reasonableness or otherwise of his anticipations, both as regards its cost and capability of supplying the very large quantity of water calculated upon by him; and at the same time to examine several other extensive reservoirs in the adjoining districts. Shortly after this I went again to Rivington with Mr. Simpson, Mr. Newlands, Mr. Rowlandson, and Mr. Binny, in order to receive from them in like manner a detail of their objections, and, in addition to this, make myself master of the whole of the views and calculations developed in the printed report of the two first-named of these gentlemen; and having done this, I carefully reviewed every difficulty that had been raised.

The first was, that the reservoirs were incapable of storing such an amount of flood-water as would maintain the uniform supply of 13,660,000 gallons a day to Liverpool, and 8,000,000 gallons a day to millowners and others throughout the usual as well as unusual droughts which sometimes occur, and that the fluctuations in the quantity of water were so extensive that at some periods of the year the reservoirs would be absolutely empty.

If even a near approach to such a state of things were probable, this objection would at once be fatal. I therefore made myself acquainted with the mode of calculation by which this is said to be proved, and which may be succinctly described as follows.

A series of rain-gauges had been carefully registered in the Belmont District, from the year 1843 to 1848 inclusive; and during the years 1847 and 1848 a similar series was also registered simultaneously by the projector of the Rivington Works in that district, with the view of establishing a relation between the amount of rain-fall in both; and the proportion found to exist was applied to the four preceding years, thus arriving at the probable rain-fall in the Rivington district during the whole six years. This mode appears quite unobjectionable, provided the levels occupied by the rain-gauges in the respective districts are identical, which is an essential condition in consequence of the total amount of rain varying very materially at different elevations.

During the years 1847 and 1848, the actual quantity of rain which flowed down the brooks of the Rivington district having been accurately measured, the proportion of available water was ascertained to be within 18 or 19 per cent. of the whole rain-fall. The quantity during the four preceding years was then modified according to the amount of fall and evaporation, and the annual yield largely reduced by the assumption that the latter was considerably greater in the drier years. These total amounts were next apportioned to each month in the four years in accordance with the registration of the Belmont rain-gauge, and thus what was supposed to be the monthly supply to the reservoirs was arrived at. The draught upon the reservoirs was then taken at a mean of 21,660,000 gallons a-day, and this quantity altered to the extent of 19 per cent. less than the mean quantity to be appropriated to Liverpool for the winter months, and a like per centage more for the summer months. It then became easy to institute a debtor and creditor account between the demand and the supply upon the reservoirs, which account exhibited the reservoirs occasionally in a state of bankruptcy.

Several objections have been urged to this mode of arriving at the result. In the first place, the total rain-fall at Rivington during the years 1847 and 1848 was obtained by averaging that represented by a series of rain-gauges, the average of which is stated by Mr. Hawksley to have occupied a position below the mean level of the area of the water-shed, and in the next place the assumption of the available quantity being in dry years less than four-fifths of the total rain-fall on the water-shed, from a supposition that the proportion wasted by evaporation was much increased; and again, that the allowance of 19 per cent. above and below the mean quantity of 13,660,000 gallons is too great; and objection is also taken to the supposition that the monthly supplies to the reservoirs are proportionate to the monthly falls of rain. This was established by reference to the tables contained in Messrs. Simpson and Newland's Report; as it appeared that in December, 1847, 8 inches of rain fell at Belmont, and 1,604,000,000 of gallons were discharged by the brooks at Rivington; whereas in December, 1845, a like quantity of rain fell, and the flow from it is calculated to yield only 1,080,000,000; and many other instances might be referred to where the same inconsistency was shown, by which the calculated quantity was sometimes more and as often less than that which was measured in 1847 and 1848.

In the objections to this project, great importance is attached to the circumstance of the mains passing over an extensive coal-field, it being said that they will consequently be liable to fracture by subsidence when the coal is worked away, and that injury may be anticipated to mines from inundations. This, at the first glance, certainly appears formidable; it was deemed so in reference to railways some years ago, and was used with success in preventing the Grand Junction passing through the densely populated mining district at South Staffordshire. The demand for accommodation, and a more dispassionate consideration of the difficulties to be expected from this source have led to its being discarded; and indeed the conclusion might have been arrived at without diverting a great line of railway out of its proper course, by the experience of the canals which intersect extensively every part of the same coal-field where the beds are very thick, and give rise sometimes to extensive subsidences. In spite of these, however, no serious impediments have arisen. Attention, of course, is essential to those parts of the canal or railway under which it is known that the operation of mining is going on; and for the purpose of protecting the public against inconvenienae as far as possible, by the extraction of coals or other minerals without the knowledge of the companies, it is made imperative on the mining proprietors to give due notice of the advance of their operation before they work under any canal or railway; and similar provisions, I believe, are applicable in the case of waterworks. This objection, therefore, I regard as of little moment in the Rivington scheme, provided in other respects it may prove the most eligible source of the supply of water to Liverpool.

Without entering here into further discussion of points which are rather of detail, and could not be made intelligible within any reasonable compass, I will state the manner in which I have proceeded to investigate this part of the subject.

There is some discrepancy in the statement of the rain-fall at Rivington in 1847 and 1848, Mr. Hawksley averaging it at 55·5 inches and Mr. Newlands at 51·7 inches; but the difference (however occurring) is of little importance in this inquiry, as the quantity of water flowing down the brooks in these years has been actually measured, and amounts to 25,718,194 gallons a day.

The years 1847 and 1848 having been wetter than the average of years, it is necessary to arrive by estimate at a fair average yield from such data as exist. The Belmont rain-gauge supplies the means of doing so, and I find, by its register, that while the years 1847 and 1848 show an average of 63·6 inches, the average of the six years (1843 to 1848) gives only 57·57 inches. These figures furnish a proximate ratio by which the yield of the brooks in 1847 and 1848 ought to be corrected; and, following them, the

		Gallons a day.
Measured quantity of 25,718,194 gallons is reduced to ..		23,279,818
Which may be assumed as the permanent yield of the district; but this, as regards Liverpool, is again subject to the following deductions, in the way of compensation to		
Mill-owners	7,500,000	
Chorley and outlying population, say ..	500,000	
Wigan	800,000	
And for waste by additional evaporation from the reservoirs	422,108	

Amounting together to .. .. .. ——	9,222,108
And leaving for Liverpool	14,057,710
But by Clause 59 of the Act the Corporation are in effect empowered to supply Wigan from another source with ..	800,000
And under Clause 62 to contract with other parties for the compensation down the Roddlesworth for	1,846,000
So that there is available for Liverpool, supposing the powers of Clauses 59 and 62 to be acted upon, ...	16,703,710

The capacity of the reservoirs is stated by Mr. Newlands to be 2,849,000,000 gallons, and by Mr. Hawksley 3,156,000,000 gallons; which difference is caused by the addition, when required, of two feet to their depth by moveable shuttles or flush-boards on the weir,—an intention probably unknown to Mr. Newlands.

The yield per day or month is only known during 1847 and 1848, and its irregularity is so great even in these years as to render it impossible to calculate with accuracy upon the quantity a month of any other year by the rain-fall only. As an instance of this, taking the month of January in each year, we find that in 1847 an inch of rain-fall produced 330,500,000 and in 1848 only 216,100,000, although in the previous month of December, 1847, 8 inches of rain had fallen, and in December, 1846, only 3·9 inches. Again, in February, 1847, one inch yielded 266,900,000, but in February, 1848, only 147,100,000, although in the month of January, 1847, only 1·9 inches of rain had fallen, and in January, 1848, 3·1 inches. This is sufficient to show the absence of a rule which would justify the construction of any balance of account for each month of those years when the actual flow was not measured, and I have therefore made out tables, showing the quantities flowing into, abstracted from, and left in the reservoir during 1847 and 1848, and propose from them to be guided in reference to the capabilities and equalising effect of the reservoirs during other years.

In these two years, 22,800,000 gallons a day might have been taken out, and still have left the reservoirs full at the end of them, and never containing less than 1,376,580,000 gallons, but in the six years from 1843 to 1848, 2,400,000 gallons a day less water woud have flowed into the reservoirs, which would have reduced this minimum quantity to about 950,000,000 gallons.

It may be fairly assumed that practically the storage capacity proposed (3,156,000,000 gallons) is sufficient to ensure the supply of about 12 or 13,000,000 gallons a day with the whole compensation, or of about 15,000,000 gallons a day with the compensation reduced according to clauses 59 and 62 of the Act of Parliament; and there will be little difficulty and no considerable expense in raising the embankment so as to increase very largely the capacity of the reservoirs, as all the lands on their margin up to a level of five feet above the present top water mark can be purchased according to the notices which have already been given, and thus a supply to Liverpool of 14,000,000 gallons a day with the whole compensation, or of 16,000,000 gallons a day with the reduced compensation, may be insured.

In support of the adequacy of the storage room, the case of the Belmont Reservoir was adduced, which, with a water-shed of 1800 acres and capacity of reservoirs of 75,000,000 cubic feet, supplies 15 feet a second for 12 hours a day on 313 days a year, or 3,463,011 gallons a day of 24 hours throughout the year. The proportion of the water-shed is about one acre to 41,666 cubic feet of reservoir; and, comparing the two reservoirs, the Belmont having delivered 3,463,011 gallons, that proposed at Rivington, with a water-shed of 10,400 acres, will be capable of delivering 23,383,103 gallons a day.

The area of water-shed of the Bolton Waterworks is 520 acres, the capacity of reservoir being 20,860,077 cubic feet, and the evidence of Mr. Jackson is to the effect that 900,000 gallons is supplied to Bolton a day, or 18 gallons to each individual. The proportion of water-shed to the content of the reservoir is one acre to 40,115 cubic feet, while the proportion at Rivington is an acre to 48,694 cubic feet. At the Manchester Works the proportion of area of water-shed and capacity of reservoirs is an acre to 34,000 cubic feet.

The statement is made as independently as possible of any assumption or hypothesis in reference to the periodical supply to the reservoirs, or the variable loss which may be due to evaporation; the meteorological facts positively established in relation to the Belmont district, being alone taken as the basis of the calculations for the purpose of analogy. The rain-fall at Belmont during the years 1847 and 1848 is compared with the actually measured discharge of the streams from the Rivington district during the same period; but as this was an unusually wet period, the average discharge of the latter district is reduced, as before stated, in the proportion pointed out by the Belmont rain-gauges over this period, and that of six years, and the only source of error which I can discover in the process arises from the possible concurrence of two or three very dry seasons consecutively.

The mode of calculation which I have adopted does not fully justify the expectation of obtaining a daily supply of 16,000,000 gallons, together with the quantity required for compensation, although expedients are within reach at a moderate expense to realise this quantity. The results leave so considerable a margin as regards the storage capacity of the reservoirs, that an uniform supply of 12 or 13,000,000 gallons a day may, in my judgment, be reckoned upon with absolute certainty.

Mr. Hawksley's estimate for engineering works and land amounts to 389,800*l*., of which 213,400*l*. is for the main pipe, leaving 176,400*l*. for the remaining works and land.

The only large item in this estimate to which the scale of prices does not apply, is in the laying of the main pipe from Rivington to Liverpool, and on this portion of the work the contingencies may be considerable; but on the whole of the remainder of the items in the estimate I do not believe that more than the usual per centage for contingencies is necessary. This observation, however, is not to be taken as applying to the item of *land*, of which valuations have been made by three parties appointed by the Corporation, and their estimate amounts to 39,408*l*., — a sum which, although much beyond the agricultural value of the land, will, from my experience in such matters, fall short of the actual cost. In the evidence of this item given before me, great stress was laid upon the onerous severances that would be occasioned by the construction of wide reservoirs, which it would be impracticable to mitigate by the formation of roads and bridges. This led me to inquire into the facts, and to examine the plans on which the various properties are designated, and they show that with one or two exceptions no actual severance will occur, in consequence of the brook leading from the head of the Anglezark Reservoir down to Horwich forming generally the boundary of the estates and townships.

In considering the adequacy of the estimate for engineering works, I have, as already stated, been guided by the prices which have been paid in this as well as other districts; and, in addition, a tender was produced in the course of the inquiry from a respectable contractor well acquainted with the locality, and who had examined the proposed works, offering to execute them on a scale nearly identical with those contained in Mr. Hawksley's estimate.

To the estimated cost of the land and works, I have added 25 per cent. to cover unforeseen works and superintendence, making the total amount 487,250*l*.; and I believe that the Rivington project is adequate to the present and prospective supply of the town of Liverpool, and may, together with all compensations, be realised at a sum of (say) 500,000*l*.

The annual expense on the supposition of a supply of eight million gallons a-day by these works, including the depreciation of the main, will be	£5,600 0*s*. 0*d*.
To which is to be added the interest on the capital of 500,000*l*. say at 4½ per cent. ...	£22,500 0*s*. 0*d*.
Giving a yearly charge of	£28,100 0*s*. 0*d*.

And for further supplies there will be an additional charge by reason of the increase of interest for money expended on filter-beds and the cost of maintaining them.

(To be continued.)

WATERWORKS IN THE UNITED STATES.

A good sample of the water supply of the American second-rate towns is to be found at Richmond, in Virginia. It consists in two water wheels (set in motion by the James River), of 18 feet diameter, by 10 feet wide, with a 10 feet fall; they are undershot. The pumps are 9 inches diameter, with a 6 feet stroke, and they lift 400,000 gallons every 24 hours for each pump. The reservoirs are placed at a height of 160 feet above low-water mark in the river, and are two in number, each being 194 feet long, by 104 feet wide, by 10 ft. 8 in. deep. The pipes from the pump-house to the reservoirs are 8 inches in diameter; and there are two filters through which the water passes previously to being distributed. The total cost of the works, without including the distribution, was about 20,000*l*.

At Philadelphia, the supply is effected by a very important

water mill, established upon the Schuylkill, near Fairmount. A dam was thrown across the river 1600 feet long, so as to deaden its velocity for a distance of six miles up the country, and to maintain a constant depth of water at the dam of 24 feet. The dam itself is inclined at an angle of 45° to the current. A canal for the navigation is constructed 900 feet long, with two locks of 6 feet fall each, opposite to the mill race. The mill race itself, in ordinary states of the river, offers an opening of 68 feet wide by 6 feet high. It can be closed at the head, and an overflow sluice is constructed to carry off the water in this case, without passing through the wheels. The race is 419 feet long, by 140 feet wide, and from 16 to 60 feet in depth.

The engine-house is built for 8 wheels and pumps; each pump lifts actually 530,000 gallons per 24 hours. It is calculated that one gallon of water raises one other gallon into the reservoirs by its action on the wheels; but this action appears to be considerably exaggerated. The wheels are 16 feet diameter, by 15 feet in width, and they make 13 revolutions in a minute; they are capable of functioning even when there is 16 inches of water over the wheel. The floods, indeed, are a serious inconvenience upon this river, for they appear to cause the mills to lose 64 hours every month. The pumps have 6 feet stroke; the water is lifted 92 feet into the reservoirs, through cast-iron pipes 16 inches diameter. The reservoirs are situated at 102 feet above the low-water mark of the Delaware, and 56 feet above the average level of the streets of Philadelphia. They are four in number, covering a surface of 6 acres, with a depth of 12ft. 3in., and they contain 22,000,000 gallons of water. The cost of constructing these reservoirs was about 29,000*l*. sterling. In consequence, also, of the very intelligent manner in which the engineers have availed themselves of the natural power furnished by the river, the annual expenses incurred to secure a supply of 3,122,644 gallons daily are only about 2,800*l*. per annum.

The Croton Aqueduct of New York is, however, the work upon which the American engineers pride themselves the most; and it must, in justice, be allowed to be an extraordinary work, although far inferior to many of those we have hitherto considered. This aqueduct was constructed at the expense of the city of New York, under the control of a commission of the Common Council. The preliminary surveys appear to have been made by Mr. David B. Douglas, and the works were executed under the superintendence of Mr. John B. Jervis.

The Croton River takes its rise from a series of large ponds, or lakes, the aggregate of whose surface areas is about 3800 acres, which are principally situated in the county of Putnam, at a distance of about 50 miles from the city of New York. The dam built for the purpose of forming the fountain reservoir is situated about 38 miles from that town; and in the precise locality in question the medium quantity of water flowing in the river is above 50,000,000 gallons in the 24 hours, whilst in seasons of drought it has never been known to fall short of 27,000,000 gallons.

The dam across the Croton is in this place raised 38 feet above the level of the river in its natural state, and by this means it sets back the water six miles up the country, forming the fountain reservoir, whose surface is 400 acres. Excavations were made wherever the shores assumed a gentle slope, so as to create a minimum depth of water of at least $4\frac{1}{2}$ feet. The available capacity of this reservoir, down to the level where the water would flow off by the aqueduct, has been estimated to be equal to 600 million gallons. The height of 38 feet, quoted above, is the height at which the aqueduct receives the water from the reservoir. The surface of this fountain reservoir is $166\frac{1}{8}$ feet above the mean level of the tides at New York; the surface of the receiving reservoir on the island is 119 feet above the same level; so that the total fall from the one to the other is $47\frac{1}{8}$ feet. The distributing reservoir is 115 feet above the mean level of the tides, and regulates the height to which the water can be delivered in the city.

The water is led from the fountain reservoir the whole length of the way in a closed conduit of masonry, except in crossing the river Harlem to reach the New York island, and in passing a deep valley in the island itself. In these cases, as the principle of the syphon was employed, cast-iron pipes were introduced.

The general description of the conduit may be considered to be as follows:—A bed of concrete is formed, consisting of three parts of sand to one of hydraulic lime worked up into a mortar, and then mixed with three parts in bulk of sharp gravel or broken stone to one of mortar; well rammed in place, not shot in, as is our very absurd English practice. Upon this the side walls are executed in rubble stone set in hydraulic mortar in the above proportions. The face of these walls is then rendered with a coat of hydraulic mortar, about $\frac{5}{8}$-inch in thickness, which is also laid on the concrete. The proportions of sand to lime in this rendering coat are two of sand to one of lime.

A facing of sound, hard, well-burnt, and carefully selected bricks, is then built up in hydraulic lime upon this coat of rendering, mostly of half-a-brick in thickness for the sides and the invert; the top is vaulted over in two half-brick rings; and, wherever it is possible, covered with four feet of earth, to remove the aqueduct from the influence of the external atmosphere. The width of the conduit at the bottom is usually 6 ft. 9 in.; at the springing of the semicircular vault 7 ft. 3 in.; the versed sine of the invert is 9 inches; the height from the chord line of the invert to that of the vault is 4 feet. Occasionally the form of the conduit varies; but the above may be considered as the general description. Under all circumstances, it is made so as to receive and to discharge 60,000,000 gallons in the twenty-four hours.

In traversing valleys, the conduit is carried upon a wall of solid masonry, executed in rubble stone, set in hydraulic mortar. The whole is then covered over with earth, carefully rammed, and the slopes pitched with dry stones. These precautions are necessary to secure the water from the severe frosts of the North American winters. The dimensions of the concrete floor of the side walls, and of the spandril filling, are increased; and the proportion of hydraulic lime to sand is augmented to one of lime to two of sand, for all parts of the work. Great pains were taken to secure the stability of the aqueduct when it was carried upon the hill side, by forming culverts, or paved drains to carry any torrential waters away from the foundations, which were cut into the hills.

Waste weirs, with sluice gates, are provided for the discharge of any surplus water, or for the purpose of leaving the aqueduct dry in case repairs should be required. There are six of these weirs in the length of the aqueduct.

Ventilators, formed of hollow cylinders of stone, 14 feet above the surface of the ground, are placed at distances of one mile apart; and every third one is made with a door to admit of inspection of the conduit. The interior diameter of the common ventilators is 2 feet; that of the ventilators with doors, 4 feet. The latter are placed by the side of the conduit, to give room for a staircase leading to the bottom; the cill of the door being made 12 feet above the lowest point of the invert. The ordinary ventilators are placed immediately upon the centre line of the aqueduct. All of them are covered over with iron gratings. Besides these ventilators there are man-holes, placed every quarter-of-a-mile asunder, about 2 feet square. They are covered with a stone damper.

The Gate-chamber at the fountain reservoir is established nearly at the bottom of the artificial lake, and is situated at the extremity of a tunnel about 200 feet long, which separates it from the reservoir itself. The centre of the tunnel is 12 feet below the surface of the water; so that floating bodies are not likely to be carried into it, nor during the winter season can any intermission take place in the supply from the reservoirs being frozen. In summer also the water will be drawn from a level where it is at a lower degree of temperature than at the surface. At the Gate-chamber are the regulating gates, and the guard gates, necessary to controul the supply.

The total distance between the fountain reservoir and the receiving reservoir is 201,117·42 feet, or 38·09 miles. The total fall is $43\frac{63}{100}$ feet. The least incline is $7\frac{1}{2}$ inches in a mile; the greatest is about $13\frac{1}{4}$ inches per mile. The syphon upon the Harlem River Bridge is $1377\frac{1}{3}$ feet long, with a difference of level between the two extremities of 2·29 feet. The other syphon in the Manhattan Valley is 4105 feet long, with a difference of level of 3·86 feet, to overcome the friction in the pipes.

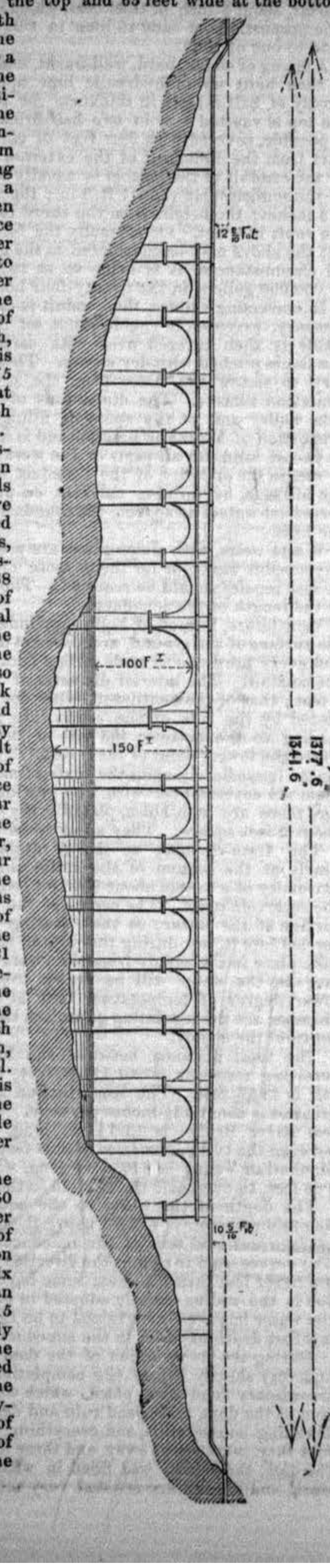
The depth of the water in the aqueduct at its entry into the fountain reservoir is $7\frac{86}{100}$ ft. above the bottom of the invert. The average sectional area of the aqueduct is made 53·34 square feet. The curves used to change the direction of the line of the aqueduct are never less than 500 feet; some have a radius of 1000 feet; but 500 is the radius usually adopted in preference. The velocity of the water has been ascertained to be $1\frac{1}{3}$ mile per hour, when there is 2 feet depth of water in the aqueduct.

During the construction of the dam at the fountain reservoir, and very shortly before the completion of the works, a most extraordinary flood took place, which carried away the greater portion of the dam, and spead ruin and desolation through the valley. Dwelling-houses, mills, and everything the stream met with in its first fury, were swept away, and three lives were lost. In repairing the dam, the breach was filled-in with masonry instead of earthwork, and it has since resisted very successfully. The masonry of

the dam is 8 feet wide at the top and 65 feet wide at the bottom, vertical to the stream, with occasional off-sets. The lower or down side has a curved face, so that the water does not fall vertically upon the apron at the foot. In order to guarantee the foot of the dam against the undermining action of the cataract, a secondary dam has been formed at a small distance to retain a head of water over the apron, so as to break the force of the water falling upon it. On the upside of the masonry of the dam a slope in earth, with an incline of 1 in 5, is executed, extending 275 feet into the reservoir at the foot. The whole length of the overfall is 251 feet.

In the course of the passage from the fountain reservoir above 11 tunnels and 14 small bridges were executed. At a point called Sing-Sing-Kill, there is, moreover, a bridge traversing a small stream of 88 feet opening, with a rise of 33 feet, of an elliptical form. The bottom of the ravine is 70 feet below the underside of the key, so that we may fairly ask why the engineer should have gone out of his way to employ the most difficult and expensive form of arch, instead of at once making it a semicircular one? The bridge over the Harlem River is, however, the great boast of our transatlantic brethren. The height from the foundations in the river to the top of the work, is 150 feet; the width across the top, 21 feet. The distance between the extremes of the pipes is 1377½ feet; for the distance of 18 feet at each end there is an inclination, the rest is upon the level. The bottom of the pipes is below the level of the aqueduct, on the upper side 12$\frac{8}{16}$th feet; on the lower it is 10$\frac{6}{16}$th feet.

On the south side of the river there is an arch of 50 feet span; across the river there are eight arches of 80 feet span each; and on the north side there are six arches of 50 feet span each; making in all 15 arches. We may justly question the policy of the engineer who has burthened the water supply with the maintenance of these syphon pipes for the sake of saving, at most, 12½ feet of additional masonry in the piers.



CROTON AQUEDUCT, HARLEM RIVER, NEW YORK (U.S.)—DATE ABOUT 1840, A.D.

There is a very important syphon in the Manhattan Valley, which carries the water over a depression of 102 feet in the deepest part. Provision is made for laying down four pipes, 5 feet in diameter. Temporarily only two are fixed, which are sufficient for the present demands of the city.

The receiving reservoirs are skilfully constructed, with a depth varying from 20 to 30 feet of water. The retaining walls are executed partly in masonry towards the streets, with a batter of 1 in 3; the inside is of earth, puddled, and covered with dry pitching, laid and dressed off to a slope of 1½ to 1. The total surface of these reservoirs is nearly 31 acres; their contents are estimated at about 150,000,000 imperial gallons.

The distributing reservoir is situated about two miles from the receiving reservoirs. It is 420 feet square on the top, with about 36 feet depth of water when full, and is calculated to hold about 20,000,000 gallons.

The total cost of the aqueduct and the reservoirs was about 9,000,000 dollars, or 1,800,000*l.* sterling, without including the pipes for the town supply. These latter, added to the above cost, make the total expense incurred by the municipality for its water supply amount to the sum of 12,000,000 dollars, or 2,400,000*l.* nearly.

GEO. R. BURNELL.

PURIFYING AND FILTERING WATER.

On the Purifying and Filtering of large bodies of Water for supplying extensive and populous Towns. By JAMES HENDERSON, C.E., Glasgow.

RAIN water, immediately after it has fallen, is generally considered the purest of all natural waters, and being the great source from which all streams and rivers are supplied and more easily obtained in large quantities than spring water, it forms the best supply for large and populous towns. But as the rains which fall on the surface of the earth collect and flow from their various sources into their different channels, and from thence into the streams and rivers which convey them back again to the ocean, they become impregnated with various earthy, mineral, and organic substances. With many of these, owing to the great solvent power which water possesses, it chemically combines; while with others it forms only a mechanical mixture, the impurities being simply held in suspension. These latter impurities, together with all insects, animalculæ, &c., can be removed by a proper system of filtration; but those which are chemically combined with the water cannot thus be separated.

The nature and quantity of the impurities in streams and rivers depend on the nature of the contributing ground, and the state of the weather; which causes, and more especially the latter, produce great variations in their purity—the same stream or river which, during a succession of fine weather, is comparatively pure, becoming, during heavy floods, loaded with a large accumulation of earthy and other impurities. This being the case, it is highly essential, that before water is let on to a filter, it should be impounded in a reservoir, so as to purify to a certain extent by subsidence.

When the stream which supplies the town is not large enough to admit of giving a sufficient quantity at all seasons of the year, the impounding of the waters becomes, of course, one of the main principles of the system, in order to retain a sufficient supply in storage when the run in the stream is deficient in dry summer weather; but when the river is large enough at all seasons to give an adequate supply, it still becomes highly essential first to impound its waters in a reservoir for the sake of subsidence; and the larger that reservoir can be obtained, so much the better. In some water-works, where the supply is from a large river, the principle of subsidence is particularly attended to, while in others the water is taken directly from the river on to filter; thus greatly increasing the difficulty of supplying pure water to the inhabitants at all seasons. Indeed, in all such water-works during heavy floods, except where some peculiarly advantageous circumstances exist, the supplying of the inhabitants with muddy water becomes almost unavoidable, the filter bed in a short time becoming so much loaded with silt as to be incapable of passing a sufficient supply, and to make up the deficiency the water has to be sent in as it comes from the river.

The impounding of the waters in large reservoirs, besides being advantageous by allowing many of the impurities to subside, owing to its thus being more exposed to the influence of the sun and air,

and the action of the winds, the waters are still further purified, as they have a tendency to give off, when thus exposed, many of the gases they may have combined with during the decomposition of animal and vegetable matter, which gases cannot otherwise be removed by filtration: it has likewise the effect of removing hardness from the water, and rendering it more fit for all domestic and other purposes. The Thames water, for instance, owing to its being much loaded with organic matter received from the towns and villages on its banks, after being kept for two or three months in a closed cask, when opened, the water is found to be black, nauseous, and unfit for use; but on being exposed and agitated it deposits a quantity of slimy mud, and becomes clear and sweet.

The water, after having been allowed to subside, the next point to be attended to is the process of filtration, in order to remove all the remaining impurities. In all filters, the great principle to which attention should be most particularly directed, is that of having a large extent of filtering surface, it being greatly owing to want of attention to such an important point that is to be attributed the inefficiency of the filters of many water-works. The great aim in the construction of many filters, is that of having the bed of sufficient fineness, so as to prevent the impurities from passing through, causing the filter bed thus to act like a sieve. Besides this, however, in order to filter water thoroughly, another important principle should be brought into operation—namely, that of attraction; and the only way by which advantage of this principle can be obtained, is by having a large filtering surface, so that the water may percolate very slowly through the filtering material.

If a stone, for instance, be suspended in muddy water, it will be found very soon coated all round with the impurities in the water, caused by the attraction which exists between the impurities and the stone, the latter, as it were, forming a nucleous to which these impurities adhere. On the same principle, if the water is allowed to percolate very slowly through the material composing the bed of filter, while the whole surface will still act like a sieve to prevent the passage of many of the impurities, each particle of the material is brought more fully into operation in removing the finer particles of the impurities carried along with the water. The filtered water is thus rendered more pure and pellucid; very fine material becomes unnecessary, and the filter bed will continue for a much longer time in good and efficient working order.

When the filter bed is too small, as the water must of course pass quickly through, fine material becomes almost indispensable, to prevent the quick percolation of the water from carrying many of the impurities with it; the consequence is, that it soon becomes silted up, and requires continual cleansing; and previous to being cleansed, recourse is not unfrequently had to that of forming holes in the material, in order to make it more open; or, as I have already observed, filter as much as they can, and make up the deficiency by unfiltered water. It may, indeed, be taken as a general principle, that the smaller the bed of filter, in proportion to the amount of filtered water required, the finer must be the material it contains, in order to remove the impurities; and, on the contrary, the larger the bed the coarser the material.

With regard to the speed with which the water should be allowed to percolate through the filtering material, much will depend on the state of the water previous to being let on to the bed of the filter. In the most of filters at water-works the speed will be found to range from 25 feet and upwards per day, and even that is not regular in many cases; but in general, the water should not be allowed to percolate more than from 10 to 20 feet per day, passed regularly through during the whole 24 hours. To many, this speed being only from 5 to 10 inches per hour, may seem much less than there is any need for; but, taking everything into consideration, water companies, by making their filters so as to come within this limit, they would be enabled to filter all the water sent in for supply, and very materially diminish the yearly expense for cleansing.

Table showing the number of Cubic Feet and Imperial Gallons of Filtered Water One Acre of Filtering Surface is capadle of furnishing, the Water being allowed to percolate through the material from 10 *feet to* 20 *feet per day.*

Feet per Day.	Cubic feet.		Imp. Gal.	Feet per Day.	Cubic feet.		Imp. gal.
10	435,600	=	2,722,500	16	696,960	=	4,356,000
11	479,160	=	2,994,750	17	740,520	=	4,628,250
12	522,720	=	3 267,000	18	784,080	=	4,900,500
13	566,280	=	3,539,250	19	827,640	=	5,172,750
14	609,840	=	3,811,500	20	871,200	=	5,445,000
15	653,400	=	4,083,750				

Water can be filtered by passing it through the material in an upward, downward, or horizontal direction; in springs it passes along in various directions, according as it finds a passage through the different strata in its course. With artificial filters, however, the same will not apply, as in the construction of these it is necessary to take into account the process of cleansing. Upward filtration is, no doubt, the best, as the sediment, on account of its weight, tends to fall downward while the water is flowing upward; but in the cleansing of such filters there are many difficulties to contend with, as since the sediment or silt lies mostly at the bottom, the whole material requires to be taken out before the silt can be either partially or wholly removed. Horizontal or oblique filtration has similar objections. In practice the downward system has been found to suit best, as the great body of the impurities lie near the surface, and the bed of filter can be partially cleansed by scraping, as is sometimes done, or more effectually by reversing the direction of the water, as will be afterwards explained.

The material through which to filter water should be of such a nature as will remain unchanged, be imputrescent, capable of allowing the water to pass through, and which does not change in its mechanical structure—such as broken granite, trap rock, and hard gritty freestone, silicious sand, pebbly and hard gravel, clean ashes, &c.; that which is most generally employed is silicious sand and gravel; broken trap rock and freestone being only used when good coarse gravel cannot be got in sufficient quantities; they, however, suit exceedingly well for a coarse filter bed, and in many cases are even preferable to the gravel. Indeed, it has been observed, that when water passes along a bed composed of rocks of the trap, or amygdaloid species, a kind of natural filtration is effected—so much so, that even moss water is rendered in some cases comparatively pure. As to the fineness of the silicious sand, none finer than that obtained on exposed parts of the coast should be used, and it is even advisable to free that of much of its finer particles. Sometimes only the finest of the sea sand is employed; but when the filter is of large extent compared to the quantity of water required to be furnished, a good bed of coarse silicious sand, plentifully intermixed with pebbly gravel, makes a much better filter. The use of fine sand is one of the great mistakes committed in many filters at present in operation, as they always become ineffective at times when most required, besides entailing a large annual expense for cleansing.

The next important matter connected with filtration is the best construction of filters, so as to act effectually, and admit of being easily cleansed. I have already observed, that the most practical system of filtration is when the water is allowed to flow downwards through the material, as by this means the filter admits of being much easier cleansed; and further, it may now be observed, that in order to get advantage of the whole surface of filter bed, the filter should be so arranged that the water, when let on, will spread equally amongst the whole material of said bed.

In many existing filters the water is let on by various openings, and the filtered water is taken away at a level with the bottom, either by drains or by a false bottom below filtering material. In such filters the water which is let on, when the material is quite clean, will be observed to spread only a small distance from the inlet, and then disappear; but as the material becomes silted up, it gradually spreads farther on to the bed of filter, and it is only when the whole is silted up that the water spreads over the entire surface. In such a filter the actual filtering surface becomes only a part of the whole, and the coarser the material the less will that part be; and, even although the whole surface be of large extent, very slow filtration is not obtained; fine material, consequently, becomes necessary, in order to cause the water to spread over a larger part of the entire surface, as well as to prevent the impurities from passing through. Were the water, by some means or other, caused to fall on the entire surface in drops like rain, the whole would be brought at once into operation, and by having a large surface slow filtration would be obtained, and fine material become unnecessary.

That of getting the water to fall equally over the whole surface not being easily attained, especially in a large filter, the next best system is that of raising the level at which the filtered water escapes, thus causing the water, as it is let on, to be dammed back amongst the filtering material, which consequently becomes fully saturated, and is all brought more or less into operation: besides, the pressure of water, by raising the outlet, being taken off, the sand bed especially does not become so soon consolidated, as will be observed to be the case when the outlet is at the lowest part of the filter. Where such a system has been adopted the water is observed to rise in the bed of filter as the material becomes silted up, forming a thin sheet over the whole surface. During hot summer weather this thin sheet of water has a tendency to become

heated and burned by the strong rays of the sun; and when there is much organic matter in the water it becomes a living mass of animalculæ, and even at some times will be found frogs, and great numbers of tadpoles. This living mass, of course, causes the sand to silt up much sooner, but generally does not affect the purity of the water when filtered, being entirely excluded by the material in filter bed; but the strong rays of a summer sun beating on the surface, by burning it, as it is termed, tends to give the water a slight taste and light brownish colour, which, although not to be detected in small, is quite perceptible in large quantities. Among bleachers this effect of the sun is a well-known fact, their pure water, by this cause, being not unfrequently rendered unfit for the required purpose. In order to avoid this, and still dam back the water, a sluice should be fixed on the outlet, by means of which the superintendent, during summer, can gradually raise or lower the level of overflow at said outlet, as he observes the water rising or falling in filter bed; by this means he can prevent the water from spreading on the surface in a thin sheet, and from being exposed and burned; and put a stop, to a great extent, to the rapid increase of animalculæ; and as for tadpoles, they could not exist. In cold weather the same precaution becomes unnecessary; in fact, at such seasons, the water is improved by being exposed in thin sheets to the influence of the sun and air.

For the cleansing of filters the system now sometimes adopted is, that of reversing the direction of the water, and conveying it away by drain, after coming to the surface, mixed with the silt. Sometimes the surface of bed is scraped—the former is, however, the better system; but on account of its not being sufficiently effectually applied, caused by the openings into drain not being properly placed, and the water sent up from below not sufficient either in quantity or pressure, in all cases where it has yet been applied its effect has been very partial, and recourse is not unfrequently had to the scraping besides; but even in such cases, although its effect in removing the silt is so deficient, still it has the tendency to improve the working of the filter bed, owing to the material being rendered more loose and open; and when often repeated, the filter bed will continue to act for a considerable time, even after it has become very much loaded with impurities. Filters for this system of cleansing are generally constructed with a false bottom, formed by brick on edge, supporting perforated tiles, the water being let into this space by means of openings or pipes when the bed is required to be cleaned.

Filters, in order to be properly cleansed by this system, should be so constructed as to admit of a large body of water being forced from below with sufficient pressure, so as to boil up and agitate the material of the filter bed, in order to free the sand of the silt; and still farther, to remove the impurities from the particles of the sand during the time that the upward current is going on, it should be well raked with a large rake; or a harrow, loaded to keep it from floating, having ropes attached, and drawn backward and forward by two men, would answer better. The effect of this raking, besides loosening the impurities, tends to spread the boiling-up of the water equally over the whole surface, and not in detached patches, as is otherwise found to be the case. By this means, the water from below, as it rises and spreads itself over the bed of filter, will gradually get loaded with impurities; and while thus loaded, were it conveyed to a drain, with a current sufficiently strong, so as to prevent these impurities from again settling on the sand, the object aimed at would be attained. In order to get a sufficient current to effect this purpose, the openings into drain should be on the same level as bed of filter, and so arranged that the run into each will be short—say about 20 feet. On drain, a sluice should be placed, so that when down the water would be prevented from getting away: it would thus keep gradually rising in the filter-bed, and if, after having acquired a depth of from 8 to 12 inches, this sluice was opened, owing to the short runs and the depth of water, there is little doubt but a strong current would be obtained, and the higher the water was allowed to rise before opening the sluice, the greater of course would be the current. In some existing filters, to cause a current, the water is let on to the surface at the same time that it is kept rushing up from below; by this system, however, it is clear there is a great loss of water, while it acts only a secondary part in the operation. But by taking all the water from below and creating a current by the system I have here mentioned, there is no waste of water, that which is used being all fully got advantage of, both for the purpose of freeing the material in filter-bed of the silt, and for creating a current to carry it, when loaded with the impurities, quickly into drain.

In order that the false bottom be enabled to stand the pressure of the water, it should be made much stronger than is generally done; the holes in tiles larger, so as to admit of the water getting freely up amongst the material; and to prevent the sand escaping from these openings, the tiles should first be covered with a layer of broken stones and gravel.

In the filtering of water, it is sometimes passed through various beds of different degrees of fineness, and sometimes only one. In cases where the water, by subsidence, can be rendered tolerably pure before being filtered, one large bed will be sufficient; but where its purity may vary much, more beds become necessary. In most cases two beds will be found quite sufficient, the one filled with a good thick bed of coarse gravel, and the other with good coarse silicious sand. If a sufficient quantity of coarse gravel cannot be easily obtained, broken granite, trap rock, or hard gritty freestone, will, as I have already observed, suit exceedingly well, continue in good working order for years, remove a large proportion of the grosser impurities, and thus render the water, before being let on to the sand bed, more equal in purity during all seasons.

In concluding these remarks on the purifying and filtering of water, I may here simply observe, that in the construction of all filters connected with waterworks for supplying large and populous towns, in order that they may be cleansed without causing the necessity of supplying unfiltered water, the filter bed should be divided into water-tight comparments, so as to admit of one part being cleansed while the others are in full operation.

BRIDGE BUILDING IN AMERICA.

At the Franklin Institute (U. S.), Mr. Solomon W. Roberts made some remarks upon bridges. He referred to the importance of economy in their construction, as large sums were often expended in such structures, when a less amount would answer the purpose. Suspension bridges, supported by iron chains or wire cables, subjected to a tensile strain, are comparatively cheap. When the material used is wrought-iron it is easy to make strong splices, but this is not the case with wood. Suspension bridges on a large scale cannot readily be built of wood, on account of the difficulty of tieing the timbers securely together and holding them fast. The bridges built by a person named Remington, about which a good deal was said in the newspapers not long ago, were wooden suspension bridges, on a small scale. It is believed that the first rude suspension bridges ever made were constructed of grape vines or some similar materials of vegetable growth. They were, of course, but of small dimensions.

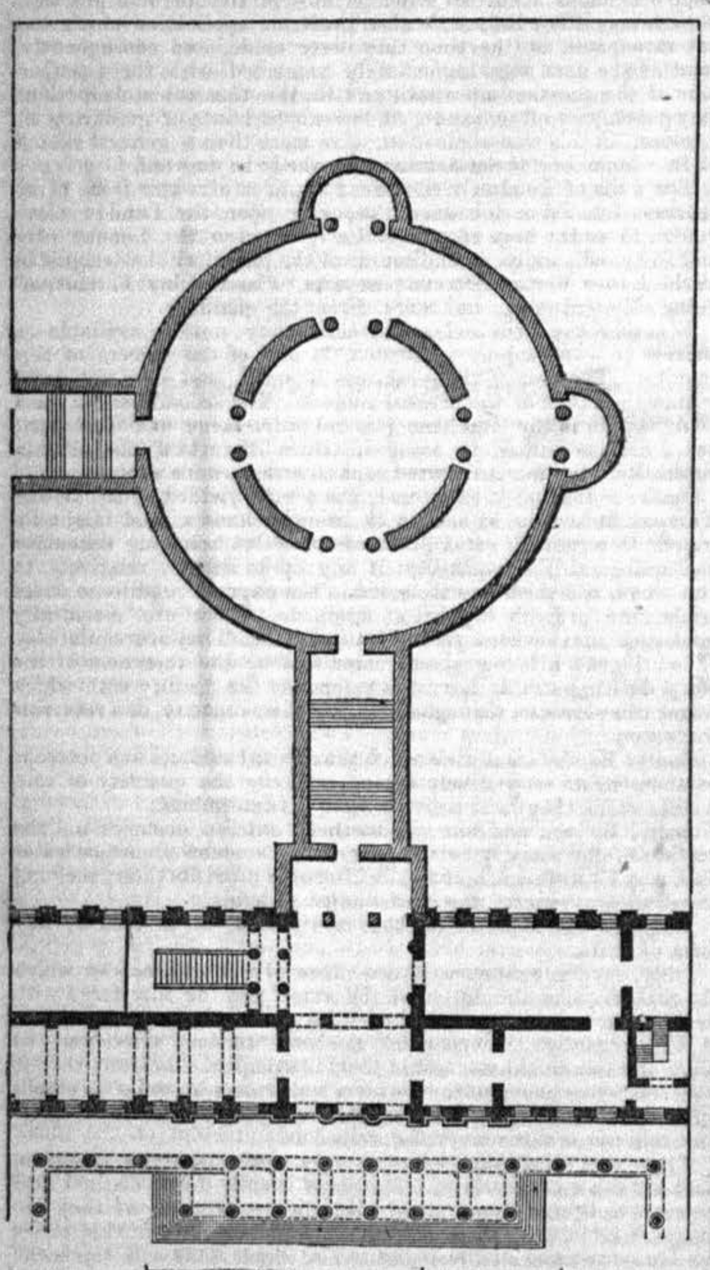
The railroads of our country abound in examples of economical bridge-building; and when we are informed that more than three millions of dollars have recently been expended in England, in building a railroad bridge about fifteen hundred feet long and one hundred feet high, it seems almost incredible. No doubt the difficulties were great, and no doubt the bridge in question is a magnificent structure: but a person accustomed to the exigencies of engineering in America shrinks from the idea of such an outlay of capital.

The wagon bridge across the Niagara river, below the Falls, is a cheap structure, the span being about seven hundred and fifty feet, and the height more than two hundred feet. It is understood that, at the same point, two able, experienced, and responsible engineers have offered to contract to build a substantial bridge for railroad trains across the most terrific torrent on the globe; and that the price asked by one was two hundred thousand dollars, and the other one hundred and ninety thousand dollars. At such prices the bridge would cost but little, if any, more than the interest for one year, at six per cent. of the cost of the tubular bridge across the Menai Strait. The cases were not alike, but they might serve to draw attention to the different circumstances under which engineering works, are executed in England and America.—*Journal of the Franklin Institute.*

The New American Gas Light.— By our advices from the United States, we learn that the excitement is still very great about Paine's system of gas-lighting by decomposing water. It is looked upon as one of the great discoveries of the age, and very strong certificates are given by those who have seen the apparatus at work, the only part kept secret being the interior disposition of the electrodes. A very strong controversy rages about Mr. Paine's abilities as an engineer, but it is certain he has long held a good standing among the practical men of his locality. Enormous sums are offered for the patent, in case he succeeds in lighting Astor House.

ANOTHER PROJECT FOR THE ENLARGEMENT OF THE BRITISH MUSEUM.

IN all probability most of our readers have seen Mr. Hosking's plan for erecting a spacious rotunda in the inner quadrangle of the British Museum; and we here submit to them another, which, whether it be a better one or not, is certainly not borrowed from his, it having been produced upwards of a twelvemonth ago, by the author of the plan and elevation of a Corinthian octastyle for the façade of the Museum, published in the *Civil Engineer and Architect's Journal*, just before the present Ionic one was begun. Indeed, it is so far from being singular that the idea of providing



additional and much-wanted accommodation, by erecting buildings for the purpose within the quadrangle, should have occurred to two individuals wholly unacquainted with each other's intentions, that the only surprising thing is that the architect of the Museum should have thrown away so much space; and not only space, but so much expensive work also, putting decorated stone fronts where they cannot be seen, while many parts of the exterior, which are in contact with, and come into view together with the façade, exhibit merely plain brick walls. Hardly does such contradictory treatment of what is exposed and what is concealed say much for either the economy or the judgment of Sir Robert Smirke—who being now professionally defunct, may be spoken of—that is, in his professional capacity, with as little ceremony as if he were actually dead and gone, more especially as we take him to be quite indifferent to either praise or censure.

Had no more regard been paid to appearance in the inner court than on the sides of the exterior, there might have been very little scruple to making alterations in the former; but now there must naturally be considerable reluctance on the part of the trustees to cut up and destroy—for destroyed it would be—what has had so much money expended upon it. Even should necessity at last get the better of not wholly unreasonable objections, desirable it would still be that additions made within the quadrangle should interfere as little as possible with any of the existing buildings around it. Nevertheless, Mr. Hosking proposes to remove a considerable portion of wall, both on the east and the west side of the court. Now, putting expense out of the question, it would be attended with exceedingly great inconvenience during the whole of the time it was being carried into effect, particularly in the Royal Library, which would, after all, hardly be improved by the alteration, unless further change were to be made, and its centre compartment be as much extended eastward as it would be westward, or on the side next the present quadrangle. Besides that any extension whatever of that library is not at all required; as it cannot be thrown open to the public, an immediate communication between it and the central rotunda, would, perhaps, be rather undesirable than otherwise. A similar remark applies to the other libraries forming the north range of buildings. Mr. Hosking appears, in fact, to have taken *carte blanche* for making alterations in, as well as additions to, the actual building; inasmuch as he further proposes that the present staircase—the most scenic bit in the whole interior—should be demolished, in order to obtain there an additional gallery. It is true, he provides a much more spacious staircase, in a line with the entrance-hall and his rotunda; and the new staircase might, perhaps, in point of architectural effect, be more striking than the existing one; as to which, however, we cannot pretend to speak from a mere plan, more especially as that part of the plan requires in the absence of a section, a good deal of verbal explanation to render it sufficiently intelligible. Still, great as the improvement might be, so much of both doing and undoing would be terribly expensive work, and likely very greatly to exceed what Mr. Hosking hints at as its probable cost.

Even were his design pruned down, the rotunda proposed by him would be not only so large, but so lofty a mass, that it would in a manner quite choke up the quadrangle, and greatly obstruct light, as the dome would be about sixty feet higher than the other buildings. Unless there be already more light than is found necessary, it would be expedient to keep whatever galleries might be erected within the court as low as possible, consistently with regard to good proportions. Whether that would be satisfactorily accomplished by the plan here exhibited, we leave it to others to decide after reading the explanation of it, which we begin by observing that alteration of what already exists would be confined to the entrance-hall; not, however, that it would be absolutely necessary, but it would be a comparatively trifling one in comparison with the great improvement effected by it, by rendering that hall much more striking in effect as well as symmetrical in plan, as the staircase would then occupy a central situation on the west side, instead of having, as at present, too much the look of being thrust into a corner. In the corridor leading from the hall to the new glyptotheca, or rotunda, would be two flights of steps leading down to the latter, which, in order to gain height, would be upon a lower level, by about ten feet, than the first hall. And so far from being at all objectionable, such descent, which would assume quite a different character from a staircase, would be found to contribute to picturesque variety; while the corridor itself—so to call it, might be made to serve in some degree as an additional gallery, although only one of approach, or a vestibule to the glyptotheca.

As regards the last-mentioned apartment, although it would resemble Mr. Hosking's in a general circularity of plan, it would differ essentially from that—and, indeed, from almost all other structures of a similar kind—inasmuch as it would form a double rotunda, an outer and an inner one, the former being a spacious circular gallery surrounding and enclosing the other. The germ of the idea may be found in the so-called Glyptotheca of the Colosseum in the Regent's Park, a most picturesque and tastefully-arranged interior; but which, being only part of an exhibition speculation, does not possess any of that prestige which usually awes the many into admiration—at least, into the hypocrisy of affecting to admire, merely because they are ashamed to confess their ignorance or their indifference.

The idea so derived is, however, differently treated, and further developed; a rotunda covered with a dome being substituted for

the small cylindrical cove containing an enclosed staircase in the Colosseum. Though far inferior in dimensions to Mr. Hosking's, and of somewhat lower proportions—viz., 75 feet in diameter, and about 70 high, it could hardly be called small, as its diameter would be considerably greater than that of the rotunda in the Bank of England (57 feet), and of the new Coal Exchange (60 feet), or, to quote what may seem authority more to the point, the central rotunda in the Museum erected at Berlin by Schinkel, which is not more than 67 English feet in diameter. No doubt, the rotunda alone would afford very insufficient additional accommodation; but, besides that, there would be an outer ring-shaped gallery, 30 feet wide and about 25 feet high, which would form room for a considerable collection of works of sculpture on each side of it. In order to avoid interfering with, or coming into contact with the buildings on the north and east sides of the quadrangle, spacious semicircular recesses or tribunes are substituted for the oblong branches of the plan, which, on the two other sides, would connect the new building with the present ones. Those two tribunes might be covered with semi-domes, and the light might be admitted from above, either through the vertex of the concavity of the dome, or through a large arched window in the lunette or arched head of the wall forming the chord of the semicircle. In the western branch from the rotunda would be flights of steps, as in the southern one, in order to ascend to the level of the west gallery, which would there be entered, as in Mr. Hosking's plan, immediately opposite the Elgin Room; but with this difference, that the gallery itself would remain untouched, as all the alteration there required would extend to little more than breaking through the wall and forming a door *beneath* the centre window on that side; the windows being 12 feet from the floor, and the connecting vestibule between that west gallery and the circular one being somewhat lower than the latter, so that its roof (a lead flat) would clear the sill of the window,—as is now done in the new portion of that west gallery, where two doors occur beneath windows.

Such descent and ascent would, it is conceived, be not inappropriate, as marking transition and creating variety; but whether desirable or not on that account, great positive inconvenience would be avoided by placing the rotunda about ten feet below the level of the present ground-floor galleries; for, assuming about thirty feet as the height of the cylindrical walls, they would rise only eight feet higher than the sills of the windows around the quadrangle, so that they would not be visible at all through the windows from within, while the dome, being so much smaller, and consequently further off than in Mr. Hosking's plan, would occasion hardly any difference at all as to light. It may further be remarked, that although it would be no more than what attention to proportion would require, the height of Mr. H.'s rotunda would be somewhat preposterous as far as purpose was concerned, excessive height not being particularly desirable in a hall or gallery intended for the exhibition of sculpture, since sculpture can be placed only on the floor, or against the lower part of the walls. And besides that, in a room 120 feet high, even large statues would show too much like mere ornamental accessories to the architecture, so lofty and spacious a room brought into immediate propinquity with the present galleries could not fail to dwarf them, and cause them to appear diminutive in comparison with it.

Should the plan here shown, and what we have said on the subject, draw forth remarks from others, either in the shape of objections or otherwise, we may have occasion to say something further; but at present we will only add, that the plan is not to be looked upon as a matured one, but merely as a general shaping out of what might be adopted, with such modification as might be held most expedient. Perhaps it would be an improvement to make the inner rotunda still smaller—to reduce its diameter to about 60 feet, and lower it in the same proportion, so as to admit of obtaining two circular galleries around it, about 25 feet wide each, instead of a single one of 30 feet in width; that would augment accommodation for exhibiting sculpture, with very little extension of plan, and, at the same time, the height of the buildings would not require to be so high by several feet, which, under the peculiar circumstances of the locale, is a most important consideration.

ARCHITECTURAL EXHIBITION.—At the meeting of the Architectural Association, on the 26th, a subscription was handed in by a member, from "An Architect," who "regrets to find the sister art to Painting and Sculpture likely to be driven, by the unkindness of her relatives, from the portals of the Royal Academy; and in the hope, ere long, that all may share a building fully adequate to the requisitions of the three."

ON THE SUPPLY OF SPRING WATER FOR THE METROPOLIS.*

On the Geological Conditions which determine the Relative Value of the Water-bearing Strata of the Tertiary and Cretaceous Series, and on the probability of finding in the lower members of the latter, beneath London, fresh and large Sources of Water Supply, tending possibly to rise to heights considerably above the lower levels of the Metropolis.†

By JOSEPH PRESTWICH, jun., Esq., F.G.S.

THE following observations are the result of inquiries connected solely with questions of pure geology. As they have, however, some bearing on a subject which is now of considerable practical importance, it has led me to give them an application which was not anticipated at the time they were made, and consequently, some of the data more immediately connected with the practical part of the question are wanting; still, the theoretical deductions may possibly be of some use. As the subject is one of great extent, I cannot, in this communication, give more than a general sketch of it. Much of the detail must necessarily be omitted.

The wells of London derive their supplies of water from three sources: 1st. From the gravel reposing upon the London clay; 2ndly. From the beds of sand and clay between the London clay and the chalk, which, in the course of the paper, will be designated as the Lower Tertiary Strata (the term "Plastic Clay Formation" being objectionable); and 3rdly. From the chalk.

Whether the beds below the chalk may not be available as sources of water supply to London, is one of the objects of this inquiry. The first of these sources is small, and does not come within the range of the present subject. The second has led from time to time to the hope that it would prove large and abundant; but from its failing, in many instances, the third has, of late especially, been much resorted to, but with variable success.

So far as London is concerned, the results yielded by the Lower Tertiary Strata and by the chalk are well known, and might be exactly determined. But in the event of its becoming necessary to inquire into the capability of any other deposit relatively to these two, it is desirable to ascertain the physical conditions under which the present supply is obtained. These are essentially geological, and have not yet been investigated. They are regulated—

1st. By the lithological character and by the thickness of the water-bearing strata, upon which depends the facility with which water can percolate through them, and their capacity, as a reservoir for water.

2ndly. By the areas over which the exposed surfaces and outcrops of these strata respectively extend, whereby the quantity of rain water, which they can receive directly, is determined.

3rdly. By the position which their outcrop occupies on the surface of the country, which governs the amount of surface water that may be absorbed, and also facilitates or prevents their receiving the drainage from off any of the adjacent lands.

4thly. By the exposed surfaces being bare, or covered by any form of drift.

5thly. By the existence of any lines of disturbance, by which the subterranean circulation of the water may be interfered with or stopped.

With regard to the first point, the lower tertiary strata vary so much in their thickness, and in their lithological character, that it is necessary to examine them over a wide range, in order to obtain any exact results, otherwise very different conclusions as to their probable water value might be arrived at.

They consist throughout of a very variable series of sands, pebbles, and mottled clays. The clays usually form distinct and separate beds, and do not blend with the sands; and, as they are not permeable, they must, in estimating the capacity of this series for water, be separated from the sands, which alone will represent the water capacity of the series. In the eastern portion of the tertiary district, the beds between the London clay and the chalk are largely developed, and sands predominate. The thickness of the series in the north-east of Kent averages about 120 feet, of which 90 to 100 feet may be sands, and the rest clays. In the north-west of Kent we find a total thickness of from 90 to 100

* Read at the Royal Institute of British Architects, July 8th, 1850.

† Since the following Paper was written, the valuable "Report of the General Board of Health on the Supply of Water to the Metropolis," has been published. Had I been aware last autumn, when my attention was more particularly directed to this subject, by the want of geological information which seemed not unfrequently to exist in the discussions of the many plans relative to different modes of supply, that such an investigation was in progress, I probably should not have thought of engaging upon this inquiry. As it however relates to geological principles of general application, as well as to a specific branch of the question, neither of which are, I find, touched upon in the "Report," I venture to submit to the "Institution" a short statement of the principal results I have arrived at.

feet, of which about 70 are sands. In that part of the tertiary district in which London is placed, a change takes place in the condition of the lower tertiary strata. The thickness of the sands diminishes, whilst the number and thickness of the subordinate beds of clay rapidly increase. It results, that beneath London the total thickness averages about 75 feet, of which 40 only are sands, and 35 clays. At Isleworth and Twickenham the thickness of the sands beneath the London clay do not exceed 15 feet, whilst that of the associated clays amounts to 60 feet. At Claremont the sands are 10 feet, and the clays 50 feet thick. Westward from these places to the end of the tertiary district at Hungerford, the mean of a number of sections gives only 11 feet of sand, whereas the clays are 38 feet thick. This reduces the water capacity of these strata within very narrow limits. The effect also of these changes, which are particularly rapid in the district a few miles westward from London, is materially to impede the subterranean flow of water, and it is probable that little, or if any, of the water absorbed at the outcrop of the lower tertiary strata in the portions of the tertiary district, from Guildford and Maidenhead westward to Hungerford, reaches London.

The second point of inquiry refers to the superficial area occupied by the strata between the London clay and the chalk, which has apparently been generally represented as much larger than it really is. From an examination of our best geological maps, this outcrop might be estimated at about 800 square miles, whereas, it is certain that the area actually occupied by the exposed surface of these strata is under 400 square miles, and of this, a portion of nearly 200 square miles is in Kent, and is, therefore, for reasons given hereafter, useless with regard to London Artesian wells. The dimension of their exposed surface and outcrops being known, the quantity of rain received on any deposit can be readily calculated; but the quantity that would be absorbed would depend upon conditions named in the third point for inquiry. It will easily be conceived, that if a stratum crops out at the bottom of a valley, the rain falling upon it, as well as any waters derived from the drainage of the adjacent hills, will remain on the surface of its outcrop, until either absorbed by it, or else removed by the surface channels, or by evaporation. This is a common form of structure in the lower tertiaries from Croydon to Hungerford, along which line they very generally form a small and narrow valley, running parallel to the higher range of the chalk. But if the outcrop of the stratum should take place midway on the slope of a hill, then much of the rain water falling on its surface will naturally drain to the lower levels, and little or no supplies from the adjacent surfaces will be received. This is the condition which holds good, to a great extent, along the northern outcrop of the lower tertiary strata from Watford, or even from Newbury, to Hertford, and also, as far as can be judged, from Hertford to Ipswich. There are other positions of outcrop; these, however, are the two principal ones.

The fourth point is one which exercises great influence on the supply of water to the water-bearing strata. If the surface of outcrop of any deposit were always bare (the mere vegetable mould excepted) as the London clay at Primrose Hill, or the chalk downs around Brighton, then, necessarily, there would be no impediment to the passage of the surface waters into any absorbent stratum; but if the stratum should be covered by any form of drift in the shape of sand, clay, or gravel, then the passage of the surface waters would be more or less impeded, according to the tenacity and thickness of the overlying mass. In geological maps this drift is not laid down, and therefore it is sometimes conceived that the underlying strata came to or near to the surface; such is, however, not at all invariably the case. Beds of drift are very generally, but at the same time, very irregularly, dispersed all over the surface of the country. In the neighbourhood of London they are largely developed, but do not much affect the southern outcrop of the lower tertiaries. On the northern line, the outcrop being commonly on the slope of the hills, the covering of drift is very partial. In Essex and Suffolk, where the lower tertiaries frequently crop out on the summit and on the brow of the hills, a thick mass of perfectly impermeable drift clay (Boulder clay of Sir Charles Lyell) overlies them, and entirely excludes at places the surface waters.

In the fifth place, whatever may be the value of any deposit with regard to its thickness or its area of outcrop, its effective power will depend upon these conditions of thickness and area acting without interruption from the circumference to the centre; for if, from any cause, the continuity of the strata should be broken or in any way interfered with, then the other conditions, howsoever favourable, are rendered more or less inoperative, according to the amount of the disturbance. In the neighbourhood of London these causes have materially impaired the efficiency of the lower tertiary strata, as a source of water supply to London. The tertiary district is traversed by two main lines of disturbance, dividing it into four unequal areas, each of which is more or less independent one of the other. One line runs nearly east and west, and forms an irregular ridge, or small anticlinal line, passing from Cliff by Gravesend and Woolwich to New Cross, and bringing up the chalk to the surface along that portion of its range. It then proceeds, apparently, to Windsor, and thence towards Maidenhead. By the operation of this line of disturbance, the drainage of the lower tertiary strata in the north-west of Kent, where they are largely developed, is prevented from passing under the large mass of London clay spread over Essex. Southward and westward of London, as the lower tertiaries do not come to the surface, their continuity is not so completely broken by this disturbance. Another line of disturbance runs nearly due north and south, and intersects the first line at Deptford, passing apparently down the valley of the Lea, crossing the Thames, and then running up the valley of the Ravensbourne. Its effects with regard to the supply of water to London are important: it intercepts—in conjunction with the first fault—almost, if not all, the drainage water of the lower tertiaries in Kent from passing to the strata below London, and in the same way, it separates to some extent the Essex district, and prevents it from contributing any large supply of water to the division in which London is placed. There are other smaller lines of disturbance, which cannot now be noticed. From all these conditions it must be apparent that, so far from the larger portion of the outcrop of the strata between the London clay and the chalk contributing to the supply of the Artesian wells at London, the contributing surface is confined to a very small section of the whole area. The whole of Kent (except possibly for a short distance between Beckenham and Croydon) must be excluded; Essex is of but slight assistance, and the district of country from Hungerford eastward to at least about Guildford and Maidenhead, contributes probably little or nothing to the water supply beneath London.

Of the remaining portion of the area, the part from Maidenhead to Hertford is generally placed under conditions unfavourable for the absorption of the rain-water, whilst the physical structure of the district between the southern line of the outcrop and London places difficulties in the way to the free passage of water. These restrictions render it probable that, of the—say 400 square miles occupied by the lower tertiary strata, probably not more than an area of 30 square miles, if so much, can be considered as contributing to the water supply of London, which is placed at the south-east corner of the north-west division, in such a position, that, instead of its being a matter of surprise that the water value of the lower tertiary strata is not greater, it is, on the contrary, an indication of what that value would be, if a similar series of arenacious strata were placed under more favourable conditions.

As evidence of the water value of the lower tertiaries, a few cases may be briefly mentioned. In Essex, where the area of outcrop is both small and very unfavourably situated, nevertheless, from the large subterranean mass and the thickness of the strata, the supply of water is general and steady. Wells of 100 to 200 feet in depth are common, and there are many from 300 to 400 feet. The water rises in most cases to above the level of the Thames, and in quantities varying from two quarts to eight gallons per minute. It must be observed, however, that, unlike the wells in London, the Artesian wells in Essex almost invariably end in the sands below the London clay, and do not often reach the chalk. In the low marshy islands at the mouth of the Thames, these wells have of late become numerous, and have proved of the greatest value. Formerly, in dry seasons, great distress used to be experienced in these districts for want of fresh water; now, there are wells in Wallisea Island 400 feet, and in Foulness Island 450 feet deep, the water in all of which rises above the surface, and furnishes a good and steady supply in all seasons.

In Kent, the Artesian wells of Sheppy may be instanced as cases of a larger supply.

To the South of London the number of Artesian wells ending in the tertiary sands is not inconsiderable, and the supply of water is large. To allude only to one set of them, we will take those which are sunk in the Valley of the Wandle, as at Garrett, near Wandsworth, and at Tooting, where there are several such wells, 130 to 160 feet deep. Some of them have been in operation for several (10 to 25) years, and they continue to overflow at the

surface at the rate of from 50 to 100 gallons per minute. At the new almshouses at Garrett, the supply from the Artesian well is 60 gallons per minute, and the water is laid on to the ground-floor of the forty-two houses, and supplies beside a small fountain in front of them.

At Kingston, Richmond, and Twickenham, the supply of water from these strata is also good. It then diminishes in proceeding westward, apparently from the thinning out of the beds of sand, and the preponderance of mottled clays in the lower tertiary strata. At Sandgate, near Chertsey, a well was sunk to the depth of 600 feet through the London clay, and ended in the mottled clays. No water was obtained. At Cobham and at Knapp-hill, near Woking, the same result was experienced. At Cobham-place, near Cobham, a well was sunk some years since through the whole thickness of the tertiary strata, commencing with the Bagshot sands, to a depth of 649 feet. The lower tertiary strata here were about 50 feet thick, of which 47 were of clay, and only about 3 to 4 feet of sand. The supply of water being small, the works were continued down further to a depth of 150 feet into the chalk; but after all, the quantity obtained was not large.

In the north-west division of the map the supply of water in the lower tertiary strata is very uncertain, and at all times small. At Norwood, in Middlesex, these strata were traversed, together with 50 feet of chalk, without finding any water; and at Hanwell, although a supply of 20 gallons of water per minute was at first obtained, yet, at the end of six years, the quantity had diminished by more than three-fourths, and other sources of supply had to be sought.

In the valley of the Lea, the Artesian wells are numerous, and tolerably well supplied. There are some at Broxbourne, several at Waltham Abbey; also at Enfield, Edmonton, and Tottenham The water rises above or near to the surface in all of them; their depth varies from 70 to 120 feet.

In London, the great number of Artesian wells has rendered it necessary to extend a large proportion of them down to the chalk, in order to obtain a better supply of water than can now be procured from the lower tertiary strata.

With regard to the much debated question as to the probable supplies of water to be expected from the chalk, there can be little doubt that a very large portion of the rain falling on any bare chalk district is absorbed at once. This is generally admitted, and is evident from the absence both of streams and also of standing waters on the surface—whether the water so absorbed passes to, and percolates freely at great depths in the chalk, or whether it remains near the surface in the upper beds, is to be determined. It is evident from the recent experiment of Professor Ansted, that the absorbent power of the chalk is very great—as much as two gallons of water per cubic foot of chalk. But so far from this property being of value as a source of free water supply, it probably favours a contrary result. For this absorbent power is, I consider, owing to a strong capillary attraction arising from the extremely fine texture of the chalk; and if such be the case, there will be a natural tendency to a rapid absorption by the upper beds of the chalk of the rain-water which falls upon its surface, but the very strength of this tendency must cause these upper beds of chalk to part with difficulty with the water so absorbed.

It will follow that it is only when the upper beds of the chalk are in a state of saturation, or when fissures allow of gravity to act on the water with a force stronger than that which solicits it by capillary attraction, that water passes deeper into the mass of the chalk. Notwithstanding these counteracting causes, as the surface of the chalk is frequently much broken and fissured, the quantity of water in its upper beds is, in many valleys, often very great. As the depth of the chalk increases, these small fissures rapidly decrease in number; but they are intersected at intervals by larger ones, which conduct part of the water to greater depths. The planes in which the flints are deposited also present unadhering surfaces and joints through which water can pass; and this, rather than a general diffusion of water in the mass, will account for the phenomenon presented in hilly chalk districts where the level of the water in wells follows nearly the surface level of the intersecting valleys; for the base of these vallies being fissured and saturated with water, this water finds probably a readier passage laterally along the planes of stratification in which the flints occur, than downwards through irregular fissures. Consequently, in sinking wells on the hills, the water is frequently found on reaching the strata which are on a level with the base of the adjacent valleys. At a certain depth in the chalk the passage of water is usually obstructed by the lower beds, known as the chalk marl, which form an almost perfectly impermeable mass, holding up the water from the upper and middle chalk, and throwing it off in numerous springs at the base of the chalk escarpment, where the angle of inward dip is not too rapid.

Unlike, therefore, strata of sand, through which water can permeate with facility in all directions, and where it will tend to take the form of large sheets co-extensive with the strata themselves, the percolation of water in the chalk is partly in the seams of bedding, and partly through fissures irregularly distributed, the direction of which can only be determined by experience. It may be compared to a mineral occurring in veins traversing a rock independently in a great measure of its stratification, and the volume and permanence of which is very uncertain; whilst, in arenaceous strata, it may be represented by the same mineral occurring in beds in any stratified deposit, of which the range is persistent and uniform, and the dimensions can be tolerably well determined beforehand.

It is also to be observed that the chalk is far from presenting a generally bare surface. On the contrary, a large portion of it in Hertfordshire and Buckinghamshire is covered by beds of a reddish drift clay, generally very tenacious and impermeable. It is from 10 to 20 feet thick, and prevents to a great extent the passage of the surface waters into the chalk. It is confined almost entirely to the summit of the hills. The valleys usually present nearly bare chalk slopes. This drift is of much less extent in Kent and Surrey.

The deepest well in the chalk is at Saffron Walden. It was bored to the depth of 1001 feet, all in chalk, and was abandoned for want of a sufficient supply of water. There are also many wells from 200 to 400 feet deep in the chalk district south of London. The very depth of these wells shows the mass not to be so water-charged as it has been frequently supposed. Water, in fact, rather percolates than permeates through the chalk. That that portion of water which finds its way through the mass of the chalk is kept up by the gault at its base, is therefore seemingly incorrect. It is more probable that it is held up almost entirely by the chalk marl.

Immediately below these latter beds is the formation called the upper greensand, which exhibits to the north and south-east of London a type so insignificant, that it would be likely to be regarded, with reference to this question, merely as a few feet of unimportant sandy beds at the base of the chalk formation itself. It must, however, be viewed over a longer range, and then it will be found to possess an importance of which the narrower limits give no indications, and to which I would call attention with regard to its value as a water bearing deposit.

At Folkstone it is only 15 feet thick, but expands to 40 or 50 feet at Merstham. At the first place it is very argillaceous, and of little value as a water-bearing stratum. It is the same at Cambridge, where it is only two or three feet thick. In Bedfordshire it is rather thicker. Taken on a line passing from Bedfordshire through London to Godstone, the lower greensand may be about 20 to 30 feet thick. Westward, however, from this line it gradually expands, slowly at first, and more rapidly afterwards, and at the same time it assumes a more distinct type, and becomes much more arenaceous and permeable. At Farnham it has attained a thickness of nearly 100 feet; near Watlington of 70 feet; at Wantage of above 100 feet; at Burbage, in the vale of Pewsey, apparently of more than 140 feet, whilst at its extremity at Devizes it is also about 140 feet thick. It therefore represents a long wedge, of which the thinner edge is beneath London, and the thicker one rises to the surface at Devizes and near Calne.

Unlike the lower tertiaries, which present such rapid changes in their lithological structure, the upper greensand presents, notwithstanding its various development, a remarkable uniformity in its structure throughout its range from the meridian of London to Devizes. It may be considered on the whole as formed of two divisions—the upper one of sands, occasionally slightly mixed with clay, and of various shades of green, generally light—the lower one of soft thin bedded or fissile, calcareous sandstone. The upper division expands more than the lower one, and, as it expands, it becomes more purely sandy and very permeable; whilst the lower division is so fissile and fissured that water can generally percolate through it with facility.

The area occupied by the outcrop of the upper greensand westward of the meridian of London is apparently about 160 square miles, of which about 110 may be effective as a source of water supply, whereas, as before mentioned, the lower tertiary possess less than 30 square miles of such surface. In their subterranean range the difference is still greater—the tertiaries spreading over an extent of about 500 square miles, and the upper greensand of

2500 square miles, in water communication beneath London. If, further, the volume of their masses, with reference only to those beds which are permeable and the area which is effective, be compared, the following is the result in round numbers, each unit representing a mass a mile square and one foot thick.

Volume of the permeable portion of the beds beneath the chalk and the London clay	10,500
Volume of the permeable portion of the upper greensand	150,000

The productive and contributing area of outcrop of the upper greensand may be considered to be four times greater, and the volume of its mass, viewed as a reservoir for water nearly ten times larger than that of the lower tertiary strata. The water in this upper greensand is everywhere held up by the underlying gault, which consist of a mass of dark grey tenacious and perfectly impermeable clay from 100 to 150 feet thick.

Below the gault is the lower greensand formation, consisting of a series of beds of loose sands and soft sandstones, with subordinate beds of clay, and groups of argillaceous strata; the sands, however, on the whole, predominate largely. As a mass, it is much more variable in mineral character than the upper greensand. It also follows a very different rule in its development; the latter thins out as it ranges eastward, whilst exactly the reverse holds good with the former. At Hythe it is, according to Dr. Fitton, 406 feet thick, whereas at Devizes it is only 13 to 20 feet thick; the decrease, however, is not gradual, for its thickness in Surrey is probably greater even than at Hythe. In Bedfordshire it may be from 250 to 300 feet thick; it gradually becomes thinner as it ranges to Norfolk on the one side, and to Oxfordshire on the other.

Without going into further details, it may be observed, that the area of outcrop of the lower greensand, with reference to the surface that might contribute to the water supply at London, appears to me not much less than 400 square miles, whilst, in its effective underground range, it is spread over an extent of about 3000 square miles, and its effective volume may be represented as a mass of 500,000 square miles, one foot thick. The great excess of these dimensions over those of the lower tertiaries need scarcely be pointed out.

The lower greensand is underlied by the Weald clay and the Kimmeridge clay, both of which are of considerable thickness (200 to 400 feet), and perfectly retentive of water. From these facts it therefore appears probable that, both with regard to areas for drainage and to capacity for water, the upper and lower greensands present conditions far more favourable than the lower tertiary strata; for their areas of outcrop are greater,—their lithological character and thickness are superior,—the position occupied by their outcrop is usually more favourable,—their exposed surfaces are generally more free from drift, and they are both, the lower greensands especially, very absorbent. These conditions determined, it remains, however, to ascertain how far they may be rendered inoperative by disturbances in the strata between their outcrop and a central point at London. The main lines of disturbance which have affected this district run nearly east and west; consequently, as the expansion of the upper greensand and its main receiving surface are to the westward of London, or parallel to these lines, the probability of the continuity of the strata being broken between Middlesex and Wiltshire is less than it would be if they were on a north and south line.

As far as my own observations go, there are apparently no faults or disturbances of a sufficient power to interrupt the underground flow of water from the outcrop of the upper greensand in Wiltshire, and more especially in Oxfordshire and Berkshire, to London. With regard to the lower greensand, the case is different. Its contributing surfaces lie northward and southward of London, and it is traversed longitudinally by some faults of considerable magnitude. The most important one runs east and west, immediately beyond the outcrop of the upper greensand and the gault at the base of the North Downs, and is of a force sufficient at places to shift the whole thickness of the lower greensand out of its true position. If this fault were continuous, and its effects equal from any point near Westerham to Farnham, then it is probable that the drainage of nearly the entire zone of exposed surface of the lower greensand—here two to five miles broad—would be intercepted by it. But lines of disturbance are rarely maintained in equal power through any great length of range; they are, as it were, intermittent; therefore, although the continuity of the lower greensand might be broken at one or more places, yet at other places it might be, and no doubt is maintained. For in a formation of so variable and arenaceous character as this, it is not necessary that each stratum should preserve its continuity. If the mass is displaced to the extent of 100 to 200 feet, provided strata of a loose sandy nature are brought into juxtaposition on the opposite sides of the fault, that will be sufficient to keep up the circulation of water from one side of the disturbance to the other, and the waters dammed back in those parts where the disturbance is greater, and the continuity completely destroyed, will pass round through such points of communication. Nevertheless, there is no doubt that the water-value of strata so affected must be lessened, and for this allowance has been made. On the zone of outcrop to the north of London there seems to be but few disturbances, or, at all events, not any of sufficient magnitude to produce great interference, except westward beyond Abingdon, where the lower greensand is entirely cut off by a fault. The previous calculations therefore only refer to the districts from Wallingford and Biggleswade, and from Farnham to Maidstone. But it is to be observed also that the lines of disturbance which so materially affect the comparatively thin and not deep-seated beds of the lower tertiary strata would be of little consequence in the deep-seated greensands, where the water-level is so far above the level of the disturbed strata. It is therefore, I think, probable that the upper and lower greensands constitute two important zones of water-bearing strata underneath London, and it next becomes a question to determine at what depth they may be met with.

The thickness of the chalk has been very variously estimated, but there are good geological grounds for presuming that the chalk underneath London is not above 600 to 700 feet thick; if, therefore, a point be taken where the tertiary strata are not above 200 feet thick, it is probable that the upper greensand would be reached at a depth not exceeding at a maximum 1000 feet, and the lower greensand at 1200 feet. Supposing this to be the case, then, as the outcrop of the upper greensand above Trinity high-water mark at London is 360 feet southward at Merstham, and 135 ft. northward beyond Hitchin; and as, with few exceptions, it continues to maintain a high and increasing level from these points westward to Calne and Devizes, where it reaches an elevation of about 450 feet; it follows that a supply of water from this source at London would probably rise to a height of from 100 to 150 feet above the level of the Thames at London. The outcrop of the lower greensand varies from 100 to 300 feet above the same level; and, as the distance of its contributing areas of outcrop from London is much less than those of the upper greensand, it is probable that its waters might rise to a height of 80 to 100 feet, or more, above the level of the Thames.

In conclusion, although the supply of water obtained from the lower tertiary strata at and around London is confessedly inadequate to the supply of a large town, yet it is, as a local supply, in many cases, of considerable value. If, therefore, with an area of outcrop of such limited extent, and a capacity of such moderate volume, the lower tertiary strata nevertheless are of not inconsiderable value as regards their water supply, then it is probable that, with dimensions in every respect so much greater, and under conditions generally so much more favourable, the upper greensand, and the lower greensand more especially, must possess a water value very considerably greater; and there appears to me to be no reason why, in the case of the upper greensand, the downs and valleys of Wiltshire and the plains of Oxfordshire and Berkshire, should not contribute their contingent to a supply of water at London, or why even a very much larger supply, amounting possibly to as much as 50,000,000 of gallons daily, if needed, should not be furnished by the lower greensand of the hills of Kent, Surrey, Buckinghamshire, and Bedfordshire. The first source of supply would be doubtless purer and better; but the latter would be more abundant, and more generally available for all ordinary purposes requiring large supplies, while, from its being naturally at a high pressure, it might be applicable, not only to sanitary improvements, but also to the ornament and convenience of the metropolis.

Monsieur D'Archiac, who has paid great attention to the subject of the water-bearing strata of the tertiary and cretaceous series of France, confirms, as the result of his experience, the rule laid down upon perfectly independent grounds by the Abbe Paramelle, in his 'Observations on Springs,' viz., "That the underground currents of water follow the same law as those which flow on the surface." This is a natural consequence of the physical structure which determines the water-sheds of a country. Applied to the case before us, it would corroborate the views advanced in this paper; for as the Thames and its tributaries effect the surface-drainage of the tertiary and cretaceous districts around London,

so would the circulation of water, in the subterranean range of the lower cretaceous strata, have a tendency to follow underground a direction corresponding to that in which it flows on the surface, and would indicate that the position of London, with reference to the probability of meeting with such sources of supply, is extremely favourable.

There are many other points I could have wished to notice, such as the fall of rain on the surfaces of the different water-bearing strata—the quantity of free water which the masses will hold, &c., but which the limits of this paper will not allow me to enter upon. Should the general conclusions be correct, and should there exist beneath London two large and important, and hitherto untouched sources of water supply, it then becomes a question how far such sources are available, and what may prove to be the quality of the water. It was not my intention, nor do I feel competent, to go beyond the theoretical part of the inquiry, the impartial discussion of which was the sole object I had in view; there are, however, a few questions of practice, and an analogous case, so strongly in point, that I cannot help making a few observations on them. The great difficulty experienced in sinking Artesian wells in London has arisen from the circumstance of the water not rising to within many feet (60 to 100) of the surface, in consequence of which it has been necessary to sink shafts through the London clay, as well as through the loose sands and clay below it; a work frequently attended with great difficulty and expense. The chalk once reached, the operation of boring to greater depths has been comparatively easy. As it is, however, probable that the water from the greensands would rise, generally, to above the surface, the whole depth could be bored, and the great expense of sinking the shafts would be avoided. The case in point to which I would refer is the Artesian well at Calais; it presents conditions so strikingly similar to those which would probably be found to exist at London, that I think it may be viewed, although unsuccessful* in furnishing a supply of water, as a fair criterion of the difficulty and expense of a like operation here.

The tertiary strata presented, probably, even greater impediments than they would at London. The first 80 feet consisted of gravel and loose wet sands; then followed a succession of clays, sands, and pebble beds, of a thickness of 161 feet—the larger part being sands. These beds belong to the lower tertiary series. Below them is the chalk, through the entire thickness of which the bore was continued 762 feet. Then followed 3 feet of a stratum, which may be the equivalent of the upper greensands, and then 24 feet of gault clay, and finally, 17 feet of hard greensand. The total depth at this point was 1047 feet. So far the work, which was begun in 1842, had been two years and-a-half in progress, but would have been completed in much less time had it not been for delays in the arrival of the necessary apparatus. The size and number of the flint pebbles, and the hardness of the chalk, also caused delay, by breaking the instruments several times. The total expense, up to this time, amounted to 48,500 francs, apart from the cost of the temporary tubes, which came to 18,471 francs. Had the work been successful, the engineer, M. Mulot, would have been entitled to the latter, together with a further sum of 10,000 francs, consequently, the expense of the work necessary to have obtained the hope for supply of water at this depth would not have exceeded 3000*l.* A further sum of 12,000 francs was afterwards voted, and the works were carried, still without success, to a total depth of 1150 feet—a depth, I believe, sufficient to reach the lower greensand at London, while the depth to which the well was first sunk would here, I think, more than suffice to reach the upper greensand. The depth of the Artesian well at Grenelle, in Paris, is nearly 1800 feet, and the yield of water about 1,000,000 of gallons per 24 hours. It rises about 120 feet above the surface, and the water-bearing strata crop out in the country beyond Troyes at an elevation of about 300 to 350 feet above the surface level of this well.

There would, therefore, I conceive, be no practical difficulty in boring through the tertiary strata and the chalk to the upper greensand beneath London. The thinness of the latter at this point renders it, of course, uncertain how far its supply of water may be interfered with by causes which have escaped notice. Should any unforeseen causes occur, which, however, I do not anticipate, then it would be necessary to continue the work deeper, so as to reach the lower greensand, which, as the upper greensand is close and compact, and underlied by clay only, would not be attended with any unusual difficulty. The great thickness and extent of exposed surface of this formation renders the chance of success much greater than with the upper greensand.

* This is probably caused by *sea*fault, of which there are apparently indications a few miles to the south of Calais. Without a more important knowledge of the district, I can, however, only hazard this opinion.

With regard to the quality of the water, the uniform character and mixed calcareous and silicious structure of the upper greensand are favourable for a supply as good, or probably rather better, than that from the chalk—probably not quite so hard. With regard to the lower greensand, although it consists chiefly of pure silicious sands, still many of the beds are ferruginous, and others of very variable mineral character; the quality of the water which would be obtained from this source would therefore be rather uncertain. Admitting that it should not be fit for domestic purposes, still it would be free from organic impurities—it would possess a uniform temperature of from 68° to 70°. (The water of the Grenelle well contains 14 grammes of solid residue in 100 litres, whilst the same quantity of Seine water contains $17\frac{1}{2}$ grammes.)

For the purposes of stand-pipes for cleansing the streets and courts for safety against fires, for public fountains, and ornamental waters (such as the Serpentine), for irrigation and for baths, I believe that a very large and important auxiliary supply might thus be obtained. Even on a limited application, eight or ten wells of this description, yielding from 6,000,000 to 10,000,000 gallons daily, sunk in different parts of London, each with a limited distributory apparatus attached to itself as a centre, would probably constitute, to a certain extent, an efficient and economical mode of supply for this object, and might prove a measure of public utility and advantage.

LATERAL STRENGTH OF STONE.

Sir—Experiments on the lateral strength of wood have already been made in abundance; but on the lateral strength of stone—that is, what weight is required to break it when supported at each end, and the weight laid on the middle of its length, I am not aware of any experiments on record.

This void is the more remarkable, considering the numerous applications of stone supported at the ends and loaded in the middle—especially in Grecian architecture—for entablatures, lintels, &c.; and in stairs, landings, balconies, platforms, &c., &c. The following experiments on a variety of stone and slate were made at the time the Chester General Railway Station was constructed, in March 1848. If you think them worth a place in your *Journal*, chiefly with a view to engage others to pursue the subject, I beg to put them at your disposal, and vouch for the greatest care having been employed to insure their accuracy:—

Entire Length.	Distance between the Bearings.	Breadth of Slate or Stone.	Depth or Thickness.	Weight of Slate or Stone.	Breaking Weight.	Deflection.
ft. in.	ft. in.	ft. in.	ft. in.	lb.	lb.	in.
			Bangor Slate.			
3 3	3 0	0 $11\frac{3}{4}$	0 $1\frac{3}{4}$	76·50	3794·75	$0\frac{3}{16}$
3 $3\frac{1}{4}$	3 0	1 0	0 $1\frac{9}{16}$	77·50	4341·50	$0\frac{3}{16}$
3 $3\frac{1}{4}$	3 0	1 0	0 $1\frac{9}{16}$	77·00	3583·00	$0\frac{3}{16}$
3 $3\frac{1}{2}$	3 0	0 $11\frac{3}{4}$	0 $1\frac{5}{8}$	78·00	3770·00	$0\frac{3}{16}$
			Llangollen Slate.			
3 3	3 0	1 $0\frac{1}{4}$	0 2	96·75	1980·00	$0\frac{1}{8}$
3 3	3 0	1 $0\frac{1}{4}$	0 2	96·75	2352·00	$0\frac{1}{8}$
3 3	3 0	1 $0\frac{1}{4}$	0 2	97·75	2922·00	$0\frac{3}{16}$
3 3	3 0	1 $0\frac{1}{4}$	0 $2\frac{1}{8}$	101·25	3770·00	$0\frac{3}{16}$
			Stourton Stone.			
3 $2\frac{1}{2}$	3 0	1 0	0 4	168·00	591·00	
			Wingerworth Stone.			
3 3	3 0	1 0	0 4		3784·75	
3 3	3 0	1 0	0 4		2773·50	
			Red Stone Quarry, South side of River Dee, Old Chester Bridge.			
3 $1\frac{1}{4}$	3 0	1 $0\frac{1}{8}$	0 4	158·00	921·00	$0\frac{1}{8}$
3 3	3 0	1 0	0 4	154·00	1302·00	$0\frac{1}{16}$
			Yorkshire Flags.			
3 $1\frac{1}{4}$	3 0	1 0	0 2	75·00	1021·00	$0\frac{1}{8}$
3 $1\frac{1}{4}$	3 0	1 0	0 2	78·00	920·00	$0\frac{1}{8}$

Note.—The Bangor Slate in each experiment was fractured straight across on top, and splintered underneath; the Llangollen Slate splintered; the Wingerworth Stone fractured nearly straight and square across; and that from the Red Stone Quarry fractured straight.

The machinery for the experiments consisted of two bars of malleable iron for supports. These were reduced to an acute angle on their upper edge, and perfectly straight longitudinally; both were fixed in blocks of wood, laid on two stone walls about 5 feet high, thus leaving enough of space for applying the weights below. These bars were laid level in the direction of their length, and level with each other; exactly parallel, and placed, as correctly as could be measured, 3 feet apart, from the angle of the upper edge of the one to that of the other. The stone or slate having been previously dressed to a uniform breadth and thickness throughout, and 3 ft. 3 in. in length, were successively—when experimented—laid on the iron bearings crossing them at right angles, and equidistant from the ends. Another iron bar, having its under-edge dressed to an acute angle and straight in its length, was laid perfectly square across the middle of the stone or slate under the experiment. This third bar of iron projected over the stone or slate, sufficient to suspend therefrom, at each end, an iron triangular frame. The bases of the triangles being horizontal and parallel to each other, served to support the weight applied to break the stone; which weight consisted of bars of iron, laid on one by one, with great caution, so as not to communicate a concussion to the weight. No steelyard or levers of any kind were used, so that the quantity of iron laid on, including the triangular frame and cross-bar being all weighed, gave the nett weight required to break the stone or slate.

Seacombe, May 30th, 1850. William Stewart.

RAILWAY POINTS AND CROSSINGS.*

Mr. Campbell, the resident engineer of the Edinburgh and Bathgate Railway, has invented some improvements in railway points and crossings, and in setting of the rails in the chairs, which have been adopted with success on the above railway. The annexed engravings show the improved points and crossings, as well as the common and the patent make.

FIG. 1 FIG. 2

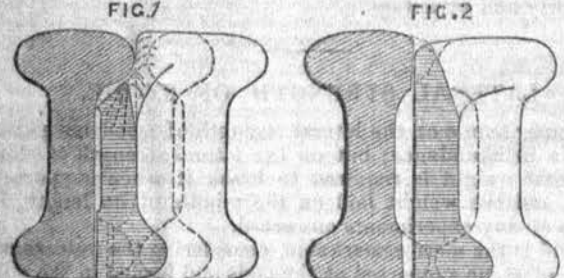


FIG. 3

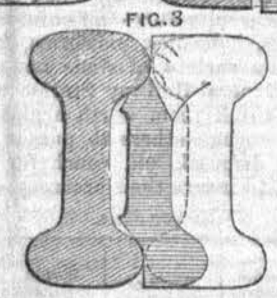
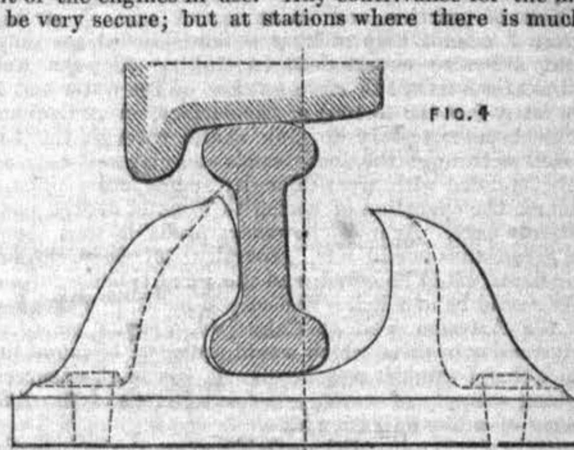


Fig. 1 is a section of the improved switch, drawn to a fourth of the full size, at the points of the switches. It is on the bottom side the same as the common switch, while on the top it resembles the patent switch; but it is simple and equally as efficient, and will stand more work. The bearing surface is neither notched nor undercut, the inside of the top of the switch being bent with a twist so as to pass under the top flange of the stock rail. The top of the switch not being mitred into the underside of the bearing surface of the stock rail, it is not liable to be locked by the barbing over of the stock from the pressure of the wheels, as frequently happens with the patent switch and others which resemble it in cutting under the top flange of the stock. In Mr. Campbell's improved switch, part of the *under* flange of the stock is cut away, which allows a broader and steadier base for the switch, and at the same time stones do not so readily rest between and prevent the shutting of the switch.

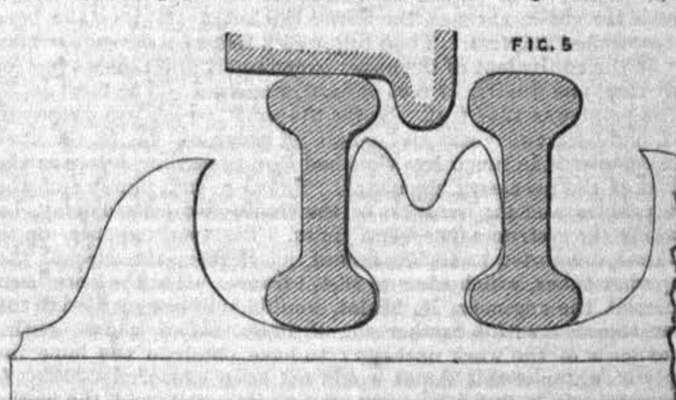
Mr. Campbell was not aware of anything having been done to meet the tear and wear of the crossing point, notwithstanding the weight of the engines in use. Any contrivance for the main road must be very secure; but at stations where there is much traffic,

FIG. 4



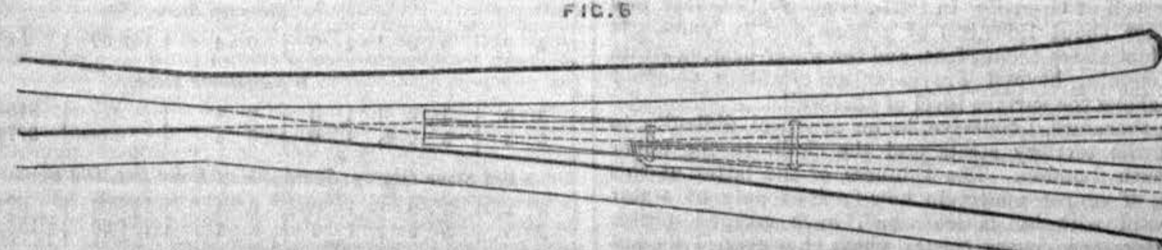
while the transit is slow, the wheels might be assisted over the interval at the crossing point by a piece of iron keyed between the rails, having its surface one inch below the top of the rail, and

FIG. 5



tapering down at each end, on which the flange of the wheel would run till the face again touched the rail, and so be prevented from falling, as it does, off the steeled point with a blow on the knee of the wing rail, which is the point that gives way. This is similar to what is done at the crossing of the bars on a turntable. The chair is laid level on the sleeper, but the seat of the rail is inclined 1 in 15 in the chair, as shown in fig. 4, so as to give the rail an equal cant its whole length, to meet the cone of the wheel. The inside jaw of the joint chair should fit close up under the flange of the rail, but the intermediate chairs should not rise quite so high,

FIG. 6



* The description is from a paper read by Mr. Campbell, at the Royal Scottish Society, 25th March, 1850.

and be slightly rounded on the inner face to allow the rail to adjust itself to the joints, which are first keyed and spiked firm.

Fig. 2 shows a section of the common switch, which possesses the advantage of a straight face and continuous bearing surface; but in consequence of it consisting of two parts, is much less durable at the point than the improved switch.

Fig. 3 is a section of the patent switch.

Fig. 4 is a section showing the cant of the rail in the chair.

Fig. 5 is a section of a check rail chair.

Fig. 6 is a plan of a crossing point.

FLOATING OF THE FOURTH AND LAST TUBE OF THE BRITANNIA BRIDGE.

The floating of the fourth and last tube, which may be said to complete this magnificent structure, came off on Thursday morning, the 25th ult., at 9 o'clock, with success.

The interest that has throughout been associated with these great engineering performances was probably heightened on the present occasion from the fact of its being the last great launching operation of the kind likely to occur in this country, and accordingly, the concourse of people present from all parts was estimated to be not far short of the thousands who thronged the Straits on the occasion of floating the first tube.

At the above hour Mr. Stephenson, M.P., Captain Claxton, Mr. Edwin Clarke, Mr. Bidder, Mr. C. H. Wild, Mr. Ricardo, M.P., Mr. Lee, C.E., Mr. Borthwick, C.E, and others, took their stations on the top of the tube, which, amid the cheers of the multitude, gradually, as the tide came up, rose upon its cradle of pontoons. The men at the mooring-chains and capstans then, in obedience to the various signalings and coloured flags, plied away at their posts, until at three minutes past 9, the huge mass, when released from its moorings, moved out into mid-stream, where under the control of the vast and intricate tackle, it made its way for full 40 minutes, until in the space of another ten, and after various nice evolutions, it came home and was safely deposited, amid artillery and cheers, on the projecting plinths of the towers. The tide taken at starting was 12 ft. 8 in., and it gradually rose until it reached a maximum of 17ft. The total distance travelled over from the starting point on the Carnarvonshire coast to the base of the towers was upwards of 300 yards. At about four minutes past 10, just as the operation was completed, the tide turned and it was high water at 32 m. past 10. The length of the tube floated was 470 feet; its weight, 1690 tons; the number of pontoons, 8; their aggregate burden, 2750 tons; the number of men engaged in the floating, 685. During the operation, the spectators were permitted to stand upon the top of the tube already in use, and which was covered with them from one end to the other. The completion of the bridge will cause the Chester and Holyhead Company to dispense with nearly 1000 workmen, who since the commencement of the works, with their wives and families, have been in constant occupation. The hydraulic presses are on the towers and will commence lifting almost immediately. The tube that has been in daily use since the 18th of March last, has presented to the most careful observation no change or alteration up to this time. The deflection found to be caused by the passage of ordinary trains daily is two-tenths of an inch, and some extreme heavy coal trains have deflected it as much as half-an-inch. The effect of joining the several tubes together, and lowering the opposite end, has been to raise them four inches, so that the most heavy trains do not counteract more than one-eighth of the advantage that was gained by this process.

An early day in November next is officially announced by the engineers as the period for the consolidation and complete public opening of the bridge.

NOTES OF THE MONTH.

Exhibition Building.—Another estimate has been sent, by another party, to the Royal Commission for the Exhibition of 1851, offering to construct a building similar in dimensions to that of Mr. Paxton, but in iron, in place of glass, for the sum of 40,000*l.*, the material to be returned to the contractor. If this offer be accepted, there will remain out of the 64,000*l.* subscribed a balance in hand of 24,000*l.* for other expenses of the Exhibition. Whereas, the estimate of the glass building being 85,000*l.*, will leave a deficiency of 21,000*l.*; and if to that sum we add 24,000*l.* for other expenses, it will make in all a deficiency of 45,000*l.* Moreover, the risk will be avoided of the calico, intended to cover the glass building, being fired with squibs or crackers, or by some accidental sparks from the neighbouring chimneys, which, in all probability, would soon break the glass and fire the goods within,—and thus terminate the Exhibition with as much confusion as it has begun.

A model of London has been made for the Exhibition of 1851, on a scale of eight inches to the mile, and containing in all ninety-six square feet. We understand that it exhibits the exact situation of all the public buildings, churches, bridges, railways, &c., with the Thames from Battersea to Rotherhithe, and shows the different elevations of the streets.

Death of Robert Stevenson, Esq., C.E.—It is with extreme regret we have to announce the death of Mr. Stevenson, the civil engineer, an event which took place on Friday, the 13th inst. Mr Robert Stevenson, had reached the advanced age of 78. The contemporary of Telford, Rennie and Stephenson (of England), needs no biography beyond an enumeration of his works. Mr Stevenson, it will be remembered, was the sole designer and executor of the celebrated Bell Rock Lighthouse, which is in itself a monument of ingenuity and industry. Sir Walter Scott, in his diary, mentions Mr. Stevenson in terms of admiration, and his impromptu in the album of the Bell Rock Lighthouse is well known. Mr. Stevenson first brought into notice the superiority of malleable iron rails for railways over the old cast-iron, a fact which has been fully acknowledged. He also surveyed the line between Edinburgh and Glasgow, and though his plan was not adopted, it was much admired. The coast of Scotland, however, is the place where the labours of Mr. Stevenson are principally to be seen. Not a harbour, rock, nor island, but bears evidence of his indefatigable industry, and it is incalculable to think of the amount of life and property which by his exertions, have been saved. In matters relating to the construction of harbours, docks, or breakwater, he was generally consulted as an authority; and received, as a mark of respect and admiration, a gold medal from the late King of the Netherlands. We may mention that in private life nothing could excel the amiability and good heartedness of Mr. Stevenson. His courtesy on all occasions was such as to render him popular with all who desired access to his presence.—*Scottish Railway Gazette.*

The Great Bull from Nineveh.—The lovers of art will be pleased to hear that the Great Bull and upwards of 100 tons of sculpture, excavated by our enterprising countryman, Dr. Layard, are now on their way to England, and may be expected in the course of September. In addition to the Elgin, Phigalian, Lycian, and Boodroom marbles, our museum will soon be enriched with a magnificent series of Assyrian sculptures. It is said at Nineveh that the French Government are determined to excel us in the exhibition of Assyrian works of art in order to compensate the comparative deficiency which the Louvre is obliged to acknowledge as to the treasures it possesses in the other great catalogues, and that large sums have been accordingly voted for the expenses of excavation. A drawing which represents the shipping of the sculpture has been just brought over by one of the Messrs. Lynch, of Bagdad, who has been with Dr. Layard exploring the remains of Nineveh. It represents the action of placing the great Bull on board the Apprentice, at Morghill, on the right bank of the Euphrates, about three miles above the old city of Bussorah. This place long formed the country residence of Colonel Taylor, lately the political agent of this country at Bagdad and Bussorah, and is now rented by Messrs. Stephen Lynch and Co., to the Hon. East India Company, as a depot for their vessels on the Euphrates. Alongside the Apprentice is the Nicotris steamer, under the command of Captain Jones, I.N., whose influence with the natives is most powerful, and to whose assistance the success in effecting the difficult operation on the muddy and deserted banks of the Euphrates is in a great measure attributable. The Apprentice was sent out from this country by Mr. Alderman Finnis, at the instance of the trustees of the British Museum, and to that gentleman and his nephews, Messrs. Lynch, the public are indebted for a periodical communication between the Thames and the Euphrates. Another vessel belonging to the alderman is, we understand, about leaving London, and it is hoped that she may in like manner return home laden with the monuments and trophies of what we had been too apt to regard as the semi-fabulous metropolis of the ancient world.

Isthmus of Panama.—The news from the Isthmus is unfavourable to the early construction of the railroad between Chagres and Panama. Impediments had occurred which were never contemplated, and, if the work is not entirely abandoned—as it is supposed it must be—it will at all events be many years before it can be completed, at a cost, too, compared with which, the original estimates are trifling. Such is the publicly avowed opinion of those who are best informed on the subject. Important modifications of the contract had been obtained from the Congress of New Grenada, among which is the conclusive privilege of constructing a plank or wagon road for temporary purposes. The immediate opening, however, of the less fatiguing, less distant, and perfectly salubrious route throug Nicaragua by the Atlantic and Pacific Ship Canal Company, will undoubtedly do away with the necessity even of this substitue for a railroad, by monopolising, as it must do, tne whole traffic of the Isthmus.

Gas.—There are now in England and Wales 560 proprietary gas-works, and in Ireland and Scotland 170. Besides these there are thirty-three which belong to private individuals, and twelve the property of municipal bodies or parish officers: in all, 775 distinct establishments for the manufacture and sale of gas. In these works a capital of 10,500,000 is said to be invested. The quantity of gas annually produced is about 9000,000,000 cubic feet, and the coal consumed in making it weighs 1,125,000 tons. The number of persons employed in its production is about 20,000; and probably an equal number finds employment in the preparatory work in the mines, ironworks and other processes connected with it. After allowing for waste and leakage, the quantity of gas actually sold to the public, in the year, is about 7200,000,000 feet, producing a light equal to what would be given out by 32,133,640 gallons of sperm oil; which at eight shillings a gallon would cost the consumers 13,253,456*l.* The gas itself is charged by the companies about 1,620,000*l.*

WHITE PAINT.—The French chymists have discovered a process by which a white paint is obtained from zinc, of a character eminently fitted for every purpose for which white lead has hitherto been applied. It would appear that during the manufacture of the zinc, a stream of atmospheric air is constantly made to disseminate itself throughout the preparation; and by this simple process the many objectionable characteristics of the zinc paint, in general, are effectually removed. The French government have awarded high honours to the discoverers, and have extended the more solid advantages of direct encouragement to the patent—the poisonous white lead having been denounced in all the public works, and the white zinc paint under notice generally adopted; nor has this been done without those necessary tests of excellence which should always mark a course which is intended as a general example. This paint is perfectly innocent, both to the artizan and to those inhabiting places covered by it. For iron it proves an immediate preservative, entering at once into the pores of the metal and producing an amalgam. The gentlemen deputed to give it the most extended publicity in this country are the Messrs. Hubbucks, opposite the London Docks, who have already made arrangements for its manufacture and economical distribution. It may be added that its application has a decided sanitary effect, and disinfects every substance upon which it is laid.

PROTECTION OF IRON FROM OXIDATION.—The following report "On the Method employed by M. Paris, for Protecting Iron from Oxidation," has been presented by M. Ebelmen to the French Society of Arts:—Various means have hitherto been employed for the purpose of protecting iron from the destructive action of air and moisture; up to the present time, the application of a thin layer of another metal to the surface of the iron has been the basis of all these methods of preservation; and tin, lead, and zinc, have all been employed for this purpose. Iron can be preserved from oxidation and destruction by covering its surface with a vitreous substance, and it is this process which M. Paris has adopted in the preparation of the various objects submitted to the notice of the Society: these objects consist of various utensils employed in domestic economy—iron pipes, chemical apparatus, sheet-iron for roofing, &c. Your committee of chemical arts have examined these specimens, with a view to ascertain whether the iron prepared by the process of M. Paris presents those conditions of solidity, strength, and durability announced by the author of the discovery. The composition which M. Paris applies to the iron is a real transparent glass, which allows the colour of the metal to be seen through it. The composition is spread with regularity, and leaves no portion of the metal uncovered—a very important circumstance. It does not peel off or crack when exposed to the direct action of the fire. Three times have we heated to redness the bottom of a prepared iron capsule, until the composition has become quite soft, and then plunged it into cold water; it was only in the third experiment that some small portions of the glaze, were detached frnm the metal in small scales. No fissure or crack was produced during this trial. Hot and concentrated acids scarcely have the slightest action on this unoxidisible iron. Such, however, is not the case with alkaline liquors. We boiled for about two hours a weak solution of a potash in one of the prepared capsules; the resulting liquor contained silex and boracic acid in appreciable quantities. We are of opinion that the unoxidisible iron of M. Paris offers the conditions of resistance and unalterability announced by the inventor; consequently, this new product appears to us susceptible of several very advantageous applications.

IVORY ENGRAVING.—The process used to cover ivory with ornaments and designs in black, consists in engraving in the ivory itself, and then filling in the designs with a black hard varnish. To obtain finer and more regular designs, the ivory is to be covered with the common ground, and by means of the point the designs are engraved upon it. They are then eaten in by a solution formed as follows:—Fine silver, 6 parts; nitric acid, 30 parts; distilled water, 125 parts (by weight). At the end of a half-hour, according to the depth to be given, it is to be washed with distilled water, and dried with bibulous paper. The design is then exposed for an hour to the solar light, and the layer of wax is removed by essence of turpentine. The design has then a black colour or a dark brown, which blackens entirely at the end of one or two days. Other colours may be produced, by replacing the solution of nitrate of silver by a solution of gold or platina in aqua regia, or of copper in nitric acid.

LIST OF NEW PATENTS

GRANTED IN ENGLAND FROM JUNE 20, TO JULY 25, 1850.

Six Months allowed for Enrolment, unless otherwise expressed.

William Saunders, of the firm of Randell and Saunders, of Bath, Somerset, stone merchants, for improvements in sawing and sawing machinery.—June 20.

John Hunt, of Stratford, Essex, engineer, for improvements in forming and moulding plastic substances, and the machinery and apparatus employed therein.—June 20.

Robert Andrew Macfie, of Liverpool, sugar refiner, for improvements in manufacturing, refining, and preparing sugar, also improvements in manufacturing and treating animal charcoal—June 24.

Henry Stephens, of Stamford-street, Blackfriars-road, writing fluid manufacturer, and Edwyn Wylder, of Paddington, Middlesex, mechanist, for certain improvements in ever-pointed pencils, pens, and penholders.—June 24.

William Laird, of Liverpool, merchant, for improvements in life boats, and in apparatus for filtering and purifying water. (A communication.)—June 24.

Joshua Vickerman Binns, of Lockwood, near Huddersfield, York, mechanic, for improvements in piecing wool cardings, and in a machinecalled a piecing-machine—June 24.

Edward Mitchell, of Great Sutton-street, Clerkenwell, gentleman, for improvements in fastenings for articles used for writing and drawing and other purposes, and improvements in articles to be used for writing and drawing.—June 24.

John Percy, of Birmingham, doctor of medicine, and Henry Wiggin, of the same place, manufacturer, for a new metallic alloy, or new metallic alloys.—June 24.

Thomas Fulljames, of Old Kent-road, gentleman, for certain improvements in machinery or apparatus for raising, lowering, and moving weights or other heavy bodies.—June 26.

James Forster, of Liverpool, merchant, for improvements in filtering water and other liquids.—June 27.

Joseph Foot, of Spital-square, Middlesex, for improvements in boilers.—June 27.

William Lancaster, of New Bond-street, Middlesex, gunmaker, for improvements in the manufacture of fire arms and cannon, and of percussion tubes.—July 3.

John Coope Haddan, of Bloomsbury-square, Middlesex, civil engineer, for improvements in the construction of carriages and of wheels, and in brickwork.—July 3.

Francis Edward Colegrave, of Brighton, Esq., for improvements in the valves of steam and other engines in causing the driving wheels of locomotive engines to bite the rails, and also in supplying water to steam boilers.—July 3.

Charles Phillips, of Bristol, engineer, for improvements in apparatus or machinery for cutting turnips and other similar substances as food for cattle.—July 3.

Richard Hornsby, of Spittlegate Grantham, Lincoln, agricultural implement manufacturer, for improvements in machinery for sowing corn and seeds, and in depositing manure in thrashing machines, in machines for depositing or winnowing corn, and in steam engines and boilers for agricultural purposes.—July 3.

James Thomson, of Glasgow, civil engineer, for improvements in hydraulic machinery, and in steam-engines.—July 3.

Richard Winter, of New Cross, Kent, gentleman, for improvements in metallic vessels for measuring and holding liquids.—July 3.

James Ward Hoby, of Blackheath, engineer, for certain improvements in the construction of parts of the permanent way of railways, and in shaping iron.—July 3.

Paul Rapsey Hodge, civil and mechanical engineer, of Adam-street, Adelphi, for improvements in certain descriptions of steam-engines, and in the apparatus and management for cultivating and manuring the soil, and in treating the produce thereof. (A communication.)—July 3.

Wakefield Pim, of Kingston-upon-Hull, engine and boiler maker, for certain improvements in the construction of the boilers and funnels of steam-engines.—July 3.

Charles Starr, of New York, United States of America, for improvements in bookbinding.—July 3.

James Kingsford, of Essex-street, Strand, Esq., for improvements in refrigerating and freezing.—July 3.

Weston Tuxford, of Boston, Lincoln, for improvements in machinery for crushing or pressing land, and for shaking straw; also improvements in applying steam-power to agricultural machinery.—July 4.

Henry Pratt, of New Bond-street, Middlesex, camp equipage manufacturer, for improvements in the construction of portmanteaus and travelling trunks.—July 9.

Alfred Vincent Newton, of Chancery-lane, Middlesex, mechanical draughtsman, for improvements in the preparation and manufacture of caoutchouc or india-rubber.—July 9.

Robert Rumney Crawford, of Warden Paper Mill, Northumberland, paper maker, for an improvement in drying paper.—July 10.

Jacob Connop, of Hyde-park, Middlesex, gentleman, for improvements in melting, moulding, and casting sand, earth, and argillaceous substances, for paving, building, and various other useful purposes.—July 10.

James Hill, of Stalybridge, Chester, cotton spinner, for improvements in or applicable to certain machines for preparing cotton, wool, and other fibrous substances for spinning and doubling.—July 15.

Tempest Booth, of Ardwick, Lancaster, gun manufacturer, for certain improvements in the method of and apparatus for obtaining and applying motive power.—July 15.

Edward N. Smith, of West Brookfield, Massachusetts, in the United States of North America, for a machine to fold paper.—July 17.

Edward John Dent, of the Strand, Middlesex, chronometer-maker, for improvements in compasses for navigation, surveying, and similar purposes.—July 17.

William Herbert Gossage, of Stoke Prior, Worcester, chemist, for improvements in obtaining certain metals from some compounds containing such metals, and in obtaining other products by the use of certain compounds containing metals.—July 17.

Jean Jules Varillat, of Rouen, France, manufacturing chemist, for improvements in the extraction and preparation of colouring, tanning, and saccharine matters from various vegetable substances, and in the apparatus to be employed therein.—July 17.

John Melville, of Upper Harley-street, Middlesex, Esq., for certain improvements in the construction of railways and locomotive engines and carriages.—July 17.

Henrietta Brown, of Long-lane, Bermondsey, widow and executrix of the late Samuel Brown, for improvements in the manufacture of metallic casks and vessels. (A communication.)—July 17.

John Silvester, of West Bromwich, Stafford, whitesmith, for improvements in straightening, flattening, setting, and shaping hardened steel.—July 17.

Ezekiel Edmonds the younger, of Bradford, Wiltshire, cloth manufacturer, for improvements in the manufacture of certain descriptions of woollen fabrics.—July 17.

Henry Bessemer, of Baxter-house, Old St. Pancras road, Middlesex, for certain improvements in figuring and ornamenting surfaces, and in the blocks, plates, rollers, implements, and machinery employed therein.—July 22.

James Bradford, of Torquay, Devonshire, jeweller, for improvements in locks and other fastenings.—July 22.

Thomas Wills, of Bow, Middlesex, engineer, for improvements in steam-engines and in pumps.—July 22.

Joseph Paxton, of Chatsworth, Derby, gentleman, for certain improvements in roofs.—July 22.

Leonard Bower, of Birmingham, Warwick, manufacturer, and Thomas Fortune, of Harborne, Stafford, mechanic, for certain improved machinery for manufacturing screws, bolts, rivets, and nails.—July 23.

William Beetson, of Brick-lane, St. Luke's, Middlesex, brass-founder, for improvements in water-closets, pumps, and cocks.—July 23.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in obtaining, preparing, and applying zinc and other volatile metals, and in the oxides thereof, and in the application of zinc, or ores containing the same, to the preparation or manufacture of certain metals or alloys of metals. (A communication.)—July 23.

George Hazeldine, of Lant-street, Southwark, Surrey, carriage-builder, for improvements in the construction of wagons, carts, and vans.—July 23.

Henry Constantine Jennings, of Great Tower-street, London, practical chemist, for improvements in rendering canvas, and other fabrics and leather, waterproof.—July 23.

William Edward Newton, of Chancery-lane, Middlesex, civil engineer, for improvements in machinery for cutting files. (A communication.)—July 23.

George Dunbar, Esq., of Paris, for improvements in suspending carriages.—July 23.

Langston Scott, of Moorgate-street, London, wine merchant, for improvements in a mode or modes of preparing certain matters or substances to be used as pigments.—July 24.

Charles William Bell, of Manchester, Lancaster, for improvements in apparatus connected with water-closets, drains, and cesspools, and gas and air-traps.—July 25.

CONDENSATION OF STEAM

Fig. 1.

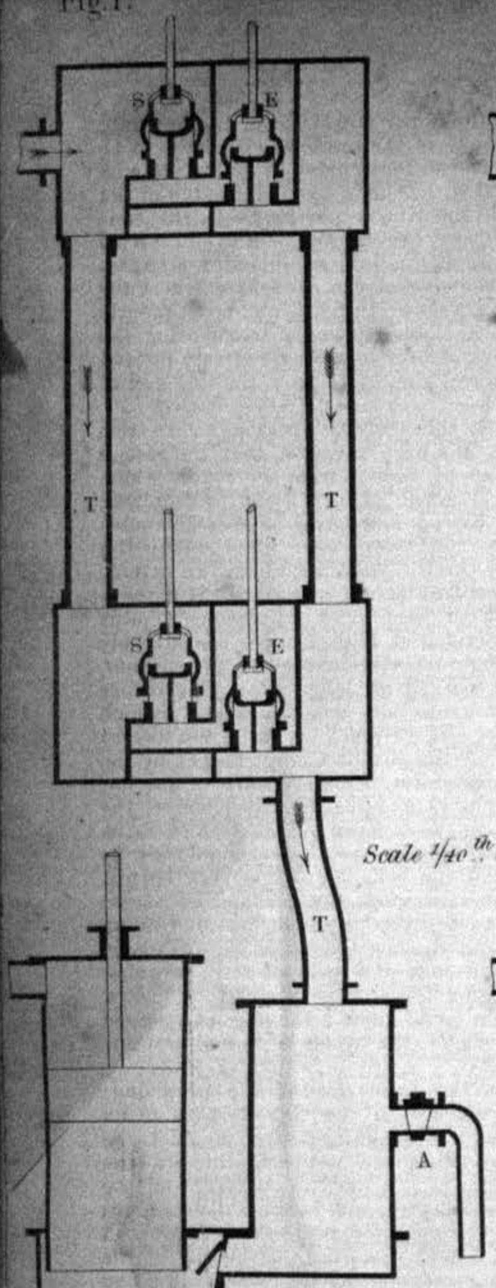
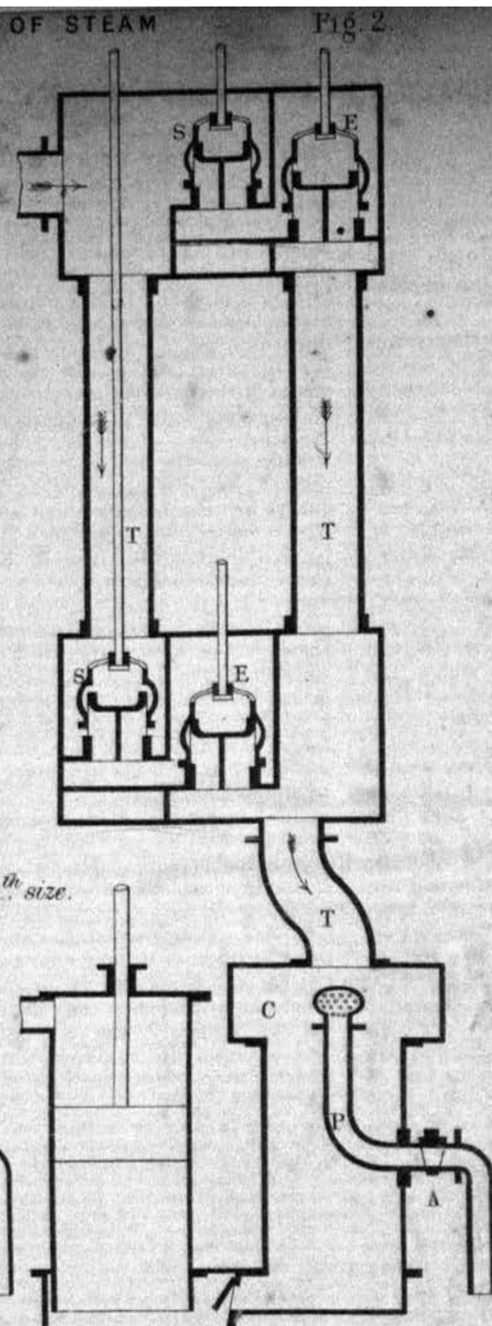


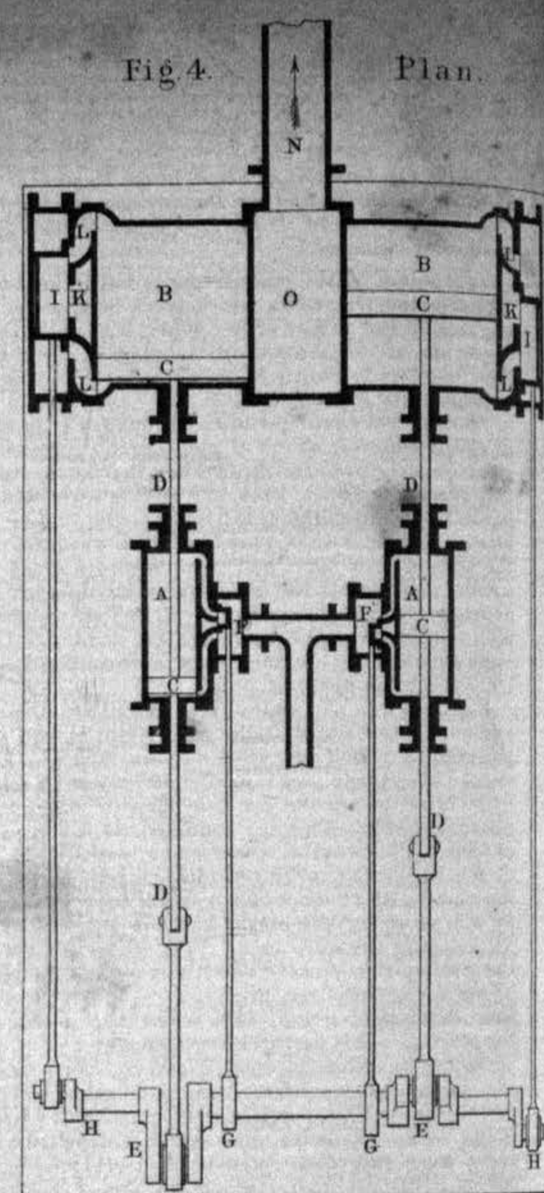
Fig. 2.



Scale 1/40th size.

BLOWING ENGINE.

Fig. 4. Plan.



Scale 1/40th size.

Fig. 3. *Diagram from Mill Engine altered.*

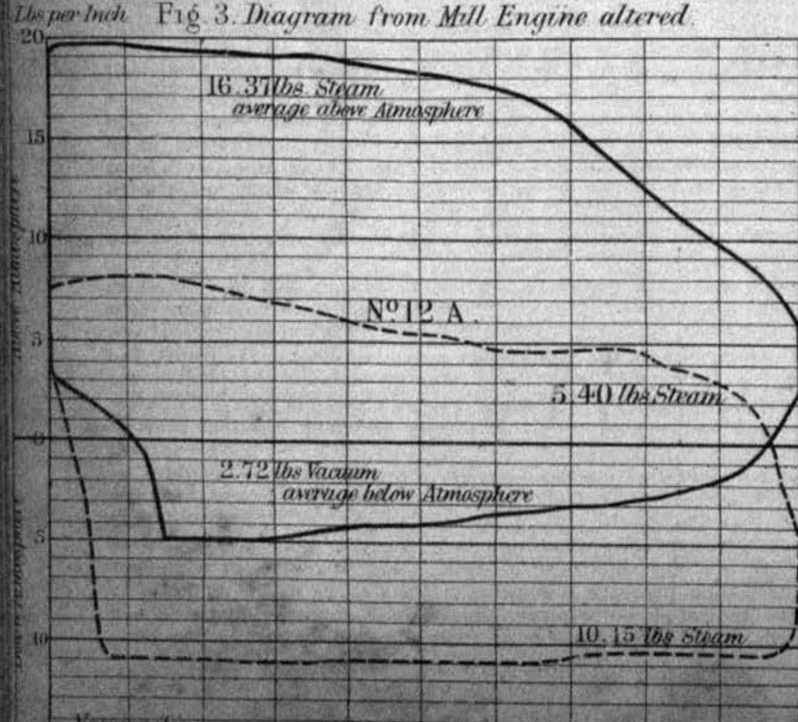
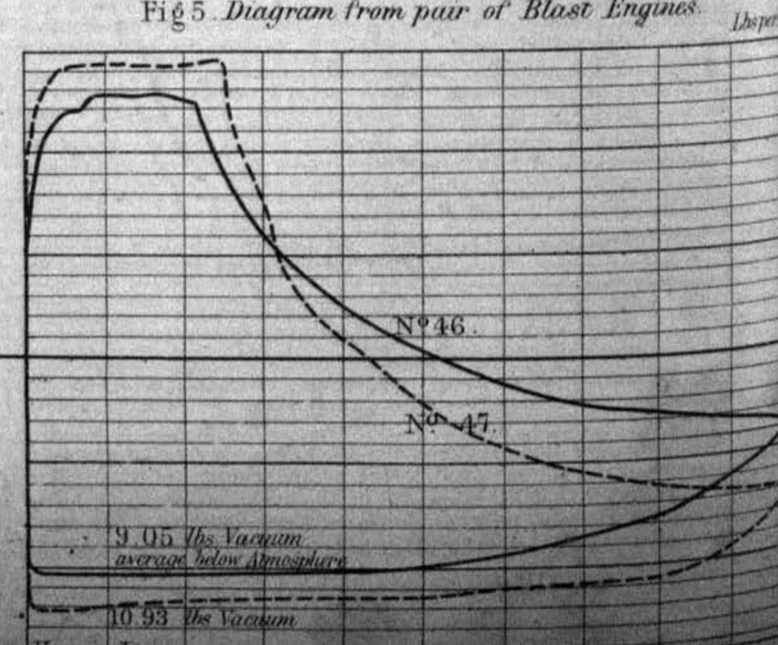


Fig 5. *Diagram from pair of Blast Engines.*



ON CONDENSING STEAM ENGINES.

(*With Engravings, Plate* X.)

On the Condensation of Steam in the Engines of the South Staffordshire Iron District, and the Improvements to be effected in them. By WILLIAM SMITH, of Dudley.—(Read at the Institution of Mechanical Engineers.)

THE object of the present paper with the accompanying series of Indicator Diagrams, which have been taken from the several engines by the author of the paper, is to show the present working condition of forty-eight of the largest class of mill, forge, and blast engines in South Staffordshire, with some remarks as to the practicability of improving them.

The general character of the Indicator Diagrams of the majority of these engines, shows a considerable pressure of steam, continued nearly uniform throughout the whole stroke of the piston, and averaging about 12 lb. per square inch above the atmosphere in the forge and millengines, and about 7 lb. per square inch in the blast engines; with a very defective vacuum, commencing about the atmospheric line, and reaching only from 7 lb. to 11 lb. per square inch below the atmosphere at the end of the stroke, the average vacuum being about $6\frac{1}{2}$ lb. per square inch below the atmosphere throughout the stroke. Some of the Indicator Diagrams from blast engines show a considerable expansive action, but not a good vacuum.

Fig. 3, Plate X. shows the Indicator Diagram from a mill engine of 42-inch cylinder and 7 feet stroke, making 17 strokes per minute, which was working very imperfectly in the condensation of the steam, and has been improved to a remarkable extent, by an alteration made for the purpose of improving the vacuum, which has effected a very considerable saving in the consumption of fuel. This engine was working with $12\frac{1}{2}$ lb. pressure of steam at the beginning of the stroke, continued to $17\frac{1}{2}$ lb. pressure at the middle, and reduced to 6 lb. per inch at the end of the stroke, by wire-drawing the steam without any cut-off expansion-valve; the average pressure being 16·37 lb. per square inch throughout the stroke; the average vacuum was only 2·72 lb. per square inch below the atmosphere, beginning a little above the atmospheric line, and reaching only 5 lb. below the atmosphere at the end of the stroke. This performance being so bad it was considered necessary to examine the engine, and the cause was found to be from the valves, thoroughfares, and condenser, being much too small for the proper proportion, the steam and eduction valves being only 7 inches diameter, and the thoroughfares of the same size; these were therefore removed and replaced by others, the steam valves being 10 inches diameter, and the eduction valves and thoroughfares 12 inches diameter, or three times the area of the original ones. The condenser was also nearly doubled in capacity by attaching a large vessel on the top of it, which made it rather larger than the regular proportion; the air-pump was only 24 inches diameter, with half the stroke of the steam piston, or about one-fifth less contents than the regular proportion for the size of the cylinder; this was not altered, but there was an abundant supply of cold water for injection.

The result of the above alteration is shown by the dotted lines 12 A, fig. 3, the steam pressure being 8 lb. at the beginning, and reduced to about the atmosphere at the end of the stroke, the average being 5·40 lb. instead of 16·37 lb. per square inch pressure throughout the stroke; the vacuum commenced at $10\frac{1}{2}$ lb. and ended at 11 lb., the average being 10·15 lb. instead of 2·72 lb. per square inch below the atmosphere throughout the stroke. The improvement in the vacuum amounts therefore to a constant average pressure of 7·43 lb. per square inch throughout the stroke; the total power of the engine as shown by the first diagram, was 19·09 lb. per inch on the piston throughout the stroke, being 190 horse-power, consequently this improvement of the vacuum amounted to 39 per cent. of the total power of the engine or 74 horse-power.

The mode of effecting the above alterations (No. 12 Engine) is shown in figs. 1 and 2, Plate X. Fig. 1 shows the engine before the alteration, the steam valves S, the eduction valves E, and the thoroughfares T being only 7 inches diameter. Fig. 2 shows the engine after the alteration, the steam valves S are increased to 10 inches diameter, and the eduction valves E and thoroughfares T are 12 inches diameter; the new valves being so much larger than the old ones, a different arrangement was required to make room for them, the spindle of the lower steam valve being carried up the side pipe, as shown in fig. 2, and the upper eduction valve placed over the other side pipe, so that three of the valve spindles are worked at the upper steam chest, and one only at the lower. The addition made to the condenser is shown at C, fig. 2, which was a circular vessel constructed of boiler plate, 3 feet 6 inches diameter, and 15 inches high, fixed on the top of the condenser. A further improvement was also made in the condenser, by cleaning out the deposit of lime, and adding an internal injection pipe and rose P; there was no internal injection pipe previously, but simply a hole in the side of the condenser, where the injection-cock A was fixed on, as shown in fig. 1, and consequently the injection water was much less efficient in condensing the steam, being poured into the condenser in a single stream instead of being scattered in a number of small jets from the rose end of the pipe.

The majority of engines in this district are similar in this respect, and the reason that has been given is, that the rose is apt to get the holes choked up by deposit from the water, which is very much impregnated with lime. This is a matter requiring particular attention in this district, and cases have come under the writer's observation, where condensers were filled up by the deposit in the course of two or three years' time, to such an extent, that the capacity was reduced fully one half, as well as the passage through the foot valve; it is a very hard calcareous deposit which adheres firmly to the cast-iron, and requires considerable labour to cut it out, involving a serious stoppage of the engines, and they were consequently worked as long as possible before taking off the condenser cover to cut out the deposit, which increased to 7 inches thickness, and as much as half a ton weight in one engine. Besides the very important saving effected by the greater power obtained from the steam, in consequence of the improvement of 39 per cent. in the vacuum, as described above, the engine has been found to do the work more regularly and satisfactorily since the alteration, than before; it was liable to be pulled up by any extra strain of the rolls, &c., whenever the piston was getting in want of repacking, the leakage of steam injuring the vacuum on account of the very deficient condensing power; but that has not occurred since the alteration was made. The engine drives a merchant mill of 3 pair of rolls, a guide mill of 3 pair, 2 pair of forge rolls, a forge hammer, 2 shears, and a pump for draining the foundations. It was not stopped longer than three days to make the whole of the alterations described above.

Another similar engine of the same size as the preceding, was also examined, in consequence of the imperfection in its condensing, and the valves and thoroughfares were found to be 10 inches diameter, but the valves had not sufficient lift, the eduction pipe to the condenser was 9 inches diameter, and the condenser was 2 feet 4 inches diameter, and 4 feet 6 inches high; the eduction pipe was then removed and replaced with one 12 inches diameter, also a large vessel was fixed on the top of the condenser, which increased its capacity about one-third. The lift of the valves was then increased from $1\frac{1}{8}$ inch to $2\frac{3}{8}$ inches, and the result of the alteration was an improvement in the vacuum of from 1·50 lb. to 7·97 lb. per square inch below the atmosphere, or 6·47 lb. per square inch increase of average pressure throughout the stroke.

The saving of fuel from these alterations has not been well ascertained, as the engines in both cases are worked from a series of boilers which also supply steam to other engines upon which the load is very unequal, but the saving is admitted to be very considerable, and in the case of No. 17, the proprietors have been enabled to use an inferior description of slack, and also to throw off one boiler, with a fire grate about 7 feet square, and 45 square yards of heated surface, without any diminution in the power employed.

The aggregate power of the 45 mill, forge, and blast engines from which the Indicator Diagrams are taken, is nominally 3240 horse-power, according to Boulton and Watt's proportions of the cylinders, but by the calculation of the Indicator Diagrams, the total is 7819-horse power; the average vacuum obtained in the present working of all the engines is about 6 lb. per inch below the atmosphere throughout the stroke, omitting from the average four, which are exceptions to the general run of these engines; and the average vacuum obtained in the six expansive engines, of which Indicator Diagrams are also given, is $10\frac{1}{2}$ lb. per inch below the atmosphere throughout the stroke. The loss of power from the imperfect vacuum in the former engines may therefore be taken at the difference between these pressures, or $4\frac{1}{2}$ lb. per square inch pressure throughout the stroke, which amounts to 1930 indicated horse-power upon these engines; or in other words, an additional power of 1930 horse-power, or 25 per cent.

increased power might be obtained from the same expenditure of steam, and consequently of fuel, if the vacuum were improved so as to be as good as the average of the six expansive engines, or $10\frac{1}{2}$lb. per inch throughout the stroke. This vacuum has been obtained in the two engines, Nos. 12 and 17, which have been altered as before described, although in these engines the alteration was carried out only to a limited extent, and at a comparatively trifling expense; but if it were carried out efficiently by attaching expansive gear in addition to the alterations that have been made, a much better effect would be obtained by using the same volume of steam expansively.

In many cases the expansive action is accomplished by the addition of a separate expansion valve in the steam pipe, which is worked by a cam, so as to cut off the steam at any portion of the stroke that may be desired, this valve opening and shutting twice for each double stroke of the engine; the steam and eduction valves are worked by a common eccentric motion, the top and bottom valves opening and shutting together. But this is an imperfect mode of obtaining expansion, because the steam filling the side pipe and the two steam chests expands after the cut-off valve is shut, and this steam forms a considerable proportion to the contents of the cylinder.

The only efficient mode of applying expansive action, is by lifting each valve by a separate cam, so adjusted as to shut each steam valve at whatever point of the stroke may be desired, whilst the eduction valve is held open till the termination of the stroke; by which means the full effect of the expansive action is obtained. The difference in effect between these two modes of cutting off the steam, is shown by the Diagrams Nos. 46 and 47, Plate X., which are taken from a pair of blast engines working coupled together, and with no difference between them except that in No. 46 the steam is cut off by a separate expansion valve in the steam pipe, and in No. 47 the valves are lifted by separate cams.

But independent of the loss sustained by not working expansively, the loss of power in the engines described being 1930 horse-power, as shown before, the annual loss in money by extra consumption of fuel in these engines, calculating 20 lb. of slack per hour, for one-horse power, at a cost of 3*s.* per ton, will amount to 18,610*l.*, or 2*l.* 7*s.* 7*d.* per horse-power per annum.

The total power of the steam engines employed in the manufacture of iron in the district, may be computed to be fully ten times the nominal power above named; and the total anuual loss to the proprietor from the causes described in the present paper, may be therefore taken in round numbers at 180,000*l.* per annum, as the more expansive engines described above may be considered a fair average of the engines in the district.

It has been generally considered hitherto, that the improvement of expansive action of steam was not applicable advantageously to the engines of this district, because of the small cost of the fuel employed; but this will be seen to be an erroneous conclusion from the actual results of the alterations described above, where the improvement was only effected in the vacuum, and the expansive principle was not carried out, which would have effected a still greater saving. The total quantity of fuel consumed at present is so large, that although the price per ton is insignificant, the total amount of saving effected by the per centage on the whole is very important.

In addition to the saving in cost of fuel consumed, a very important saving would also be effected in the tear and wear of the boilers, which is fully in proportion to the extra fuel burnt under them, and the repairing of which is invariably attended with serious inconvenience and expense.

The description of boilers in general use in the district, and the further saving to be effected by improvements in their construction and mode of setting, is also an important practical subject for consideration, and is intended to form the subject of another paper, to be laid before the Institution at a future meeting.

Remarks.—Mr. M'CONNELL said, he believed the writer was quite within bounds, when he estimated the saving in fuel which might be effected in that district alone, at 180,000*l.* per annum; nor was the subject of importance in that light merely, because it was found to prevail as a general rule, that the amount of destruction in machinery and boilers was nearly in proportion to the quantity of fuel consumed. He had remarked at a former meeting on the practical importance of obtaining comparative accounts as complete as possible of the consumption of fuel, and economy of working of the steam-engines in the different districts of the country, and he thought that all information of that kind was of great practical value.

Mr. BOWMAN inquired whether, in most of the engines mentioned, the proportions of Boulton and Watt were observed in the condenser?

Mr. W. SMITH replied, that speaking generally he believed that was the case, but the bad working of the engines was accounted for by the extraordinary pressure of the steam used. The error was, that engines intended and proportioned for 3 lb. steam were worked up to 12 lb. or 16 lb. per inch throughout the stroke, and consequently, they were very imperfect in their condensing; as there was so much larger quantity of steam to be condensed at each stroke, when the cylinder full of high pressure steam expanded down to the same pressure as the low pressure steam.

Mr. BOWMAN observed, that this would seem to imply that the size of the condenser should be regulated by the pressure of the steam in the cylinder.

Mr. COWPER said, the pressure of the steam was certainly a necessary element to be taken into consideration, as well as the size of the cylinder, in determining the size of the condenser. There was not only a greater quantity of steam to condense when a higher pressure was employed, but also a greater quantity of air to pump out at each stroke of the air pump. He mentioned a case which came within his own observation in that district, where 18 lb. steam was employed; there was no barometer guage, but the parties were satisfied that they had a good vacuum; however the fact was, that the injection water was forced into the condenser by means of a cistern at the top of the engine house, 22 feet in height.

Mr. SLATE remarked, that he fully concurred in the results obtained by Mr. Smith, but feared they were so startling that there would be a disinclination to give them credence in the district. It was highly important then that the truth of the deductions should be practically admitted

Mr. T. THORNEYCROFT, as an iron-master of the district referred to, felt extremely obliged to the author of the paper pointing out the means whereby any saving could be effected, more especially at a time when, owing to the state of the trade, economy in the manufacture was so essential.

Mr. W. SMYTH said, it had often occurred to him, that a steam engine was like no other machine. A time-piece, if out of order, was sent back to the maker to be repaired; and in the case of machines of other descriptions, if they did not do their work well they were immediately stopped, because they wasted and injured the material upon which they were employed. But when the old steam-engine, after twenty or thirty years' of hard labour, showed some symptoms of disorder, it could not be stopped, so with an extra application of the coal shovel, and some hammering at the cotters, &c., it was set to work again, and with its powerful steam arm it wound round all the complicated machinery. This, however, was done at an enormous expense to the proprietor of the engine, and it would be much better if he were to renovate its constitution. He trusted that the exertions of the members of the Institution would have some influence in showing to persons of the description referred to, the necessity of carrying out these things on more efficient principles than they had hitherto been conducted.

Mr. BOWMAN thought it a matter of great importance that the injection water should spread itself out amongst the whole quantity of steam immediately on its passage into the condenser, and the alteration made by Mr. Smith in the mode of injection was very advantageous.

Mr. COWPER observed, that they ought all to add their testimony to the value of the Indicator Figures produced by Mr. Smith, because they showed the character of the engines much better than any judgment which could be formed with reference to them, inasmuch as it was the character of each engine written by itself, and could not be erroneous. He had not the slightest doubt, that a loss of 180,000*l.* at least, as stated by Mr. Smith, was sustained in that district, because the mode of condensing ordinarily adopted was exceedingly defective. It had occurred to him many years ago, that a valve might be put at the side of the condenser, and connected with an injection pump, so that a gush of cold water might be injected at every stroke, at the very moment of the entrance of the steam into the condenser, and shut off again immediately, by which means the greatest possible use might be made of the injection water, and the condensation of the steam effected with a smaller quantity of injection water. He then explained the drawing of an improved injection valve which he had constructed, and found to work very successfully; the object was to maintain the full pressure of the water at the point of entrance into the condenser, and to obtain a more efficient distribution of the jet of water without danger of its getting choked. In fig. 5, A is the